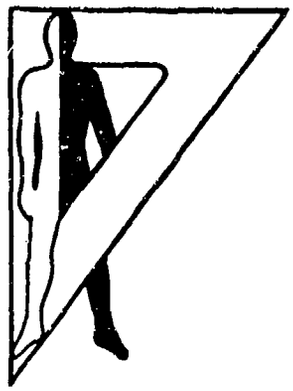

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Technical Memorandum 27-75

A HUMAN FACTORS ENGINEERING COMPATIBILITY ASSESSMENT OF THE DH-132 HELMET, COMBAT VEHICLE CREWMAN (CVC)

Nonnie F. Dickinson
Charles W. Houff
Chester L. Woodward

December 1975

U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

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The assessment of the DH-132 Helmet was conducted in November 1972. It investigated the compatibility and interface of the DH-132 Helmet System with associated equipment, as a component of a protective system and as an individual helmet.

This report explains in general terms and pictorially demonstrates those areas of concern that have not been sufficiently addressed in the design of an individual helmet system or its interfacing with its associated equipment.

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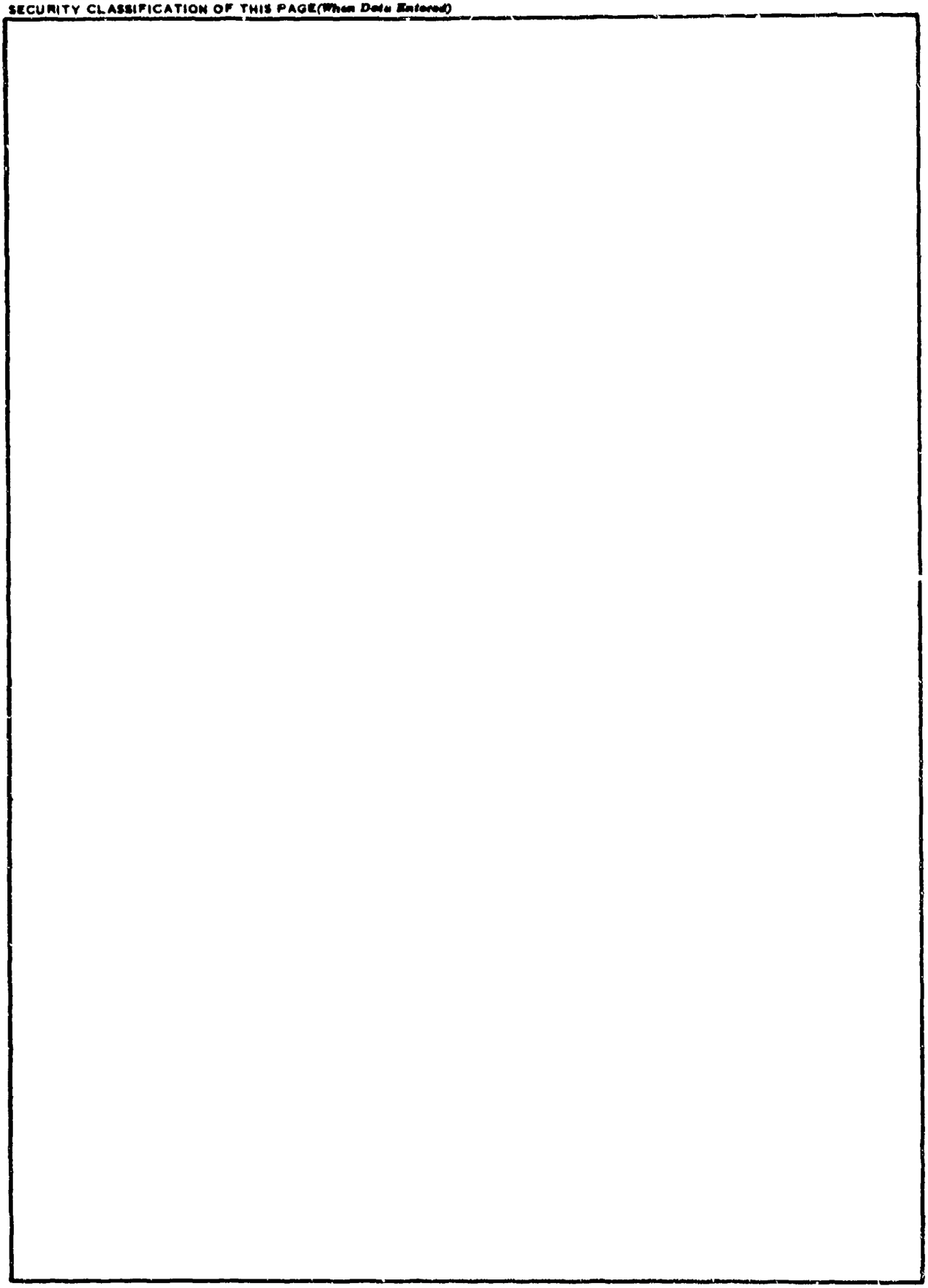

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APPROVED:
JOHN D. WEISZ
Director
U. S. Army Human Engineering Laboratory

U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

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A HUMAN FACTORS ENGINEERING COMPATIBILITY ASSESSMENT OF THE DH-132 HELMET, COMBAT VEHICLE CREWMAN (CVC)

INTRODUCTION

In support of TECOM Project No. 1-EI-820-132-01, Engineering Test of the Model DH-132 Helmet System (paragraph 2.2.3, Engineering Test of Model DH-132 Helmet, Test Plan, March 1972) and by request of the Materiel Test Directorate, Aberdeen Proving Ground, Maryland, the U. S. Army Human Engineering Laboratory conducted a related human-factors assessment of the DH-132 Helmet System. This assessment aimed to determine the compatibility and interface of the DH-132 Helmet System with associated equipment, both as a component of a protective system and as an individual protective helmet. The basic assessment included, but was not limited to, a subjective evaluation to obtain information for comparing the DH-132 with the standard T-56 Helmet. Assessing the DH-132 as an individual protective helmet includes its fit and comfort on the individual crewman—that is, its interface with the applicable anthropometric features of the head—as well as analysis of operational and design features that would affect its intended use and specified performance; and possible effects on individual task and system performance in an operational or training environment. On the other hand, assessing the helmet as a functional component of a protective system emphasizes the helmet system's interface with associated protective equipment such as browpads, goggles and protective mask, when the helmet is worn in the required operational attitude.

METHOD

To take best advantage of the specialized expertise available, HEL requested the U. S. Army Development and Engineering Directorate (DED), Edgewood Arsenal, Maryland, to assess the DH-132 Helmet System's compatibility and interface with the M25A1 Protective Mask and MS Protective Hood. Their conclusions are incorporated in this report, and their full report is included in Appendix A.

Subjects

HEL used two Army enlisted men, one warrant officer, and four civilians as subjects. All were experienced in tank-type vehicles and had participated in previous operational and tracking performance studies. Each individual subject was fitted with the DH-132 Helmet as required. The standard T-56 Helmet was also issued to each subject.

DED used 15 medical volunteer subjects. They were selected so their head sizes would accommodate the available helmet size.

Supporting Personnel

Supporting personnel included one research-and-development coordinator, one research psychologist, two human-factors specialists, one photographer and three field-support mechanics.

Equipment

Vehicles and Fire Control

M60A2 Tank

M50, Periscope (Gunner) with full browpad, Type 2

M126 Telescope (Gunner) with full browpad, Type 2

M60A1 Tank (Standard and Modified)

M31 Periscope (Gunner) with full browpad, Type 1

M32 Periscope (Gunner) with half-bar browpad, Type 3 day element, and half-browpad, Type 4 night-vision element

M105 Telescope (Gunner) with half browpad (left-eye viewing), Type 4

M17 Rangefinder (Commander) full browpad, Type 1

M60A1 Tank Turret (Product Improved, Prototype)

M105 Telescope (Gunner) with half browpad (left-eye viewing), Type 4

M32 Periscope (Gunner) day and night vision elements with full browpads, Type 2

M551 Armored Airborne Reconnaissance Vehicle

M44 Periscope and M119 Telescope (both Gunner) with full bar-browpad, Type 5

Clothing: Military and civilian normal summer wear with field jackets

Head Gear

Four DH-132 Helmets (test item)

Six T-56 Helmets (control item)

CBR Equipment

M25A1 Protective Mask

M5 and M7 Protective Hoods

Goggles

M1944 (Driver) sun, wind and dust (Fig. 35)

Eye Protectors (Laser) (Fig. 32)

Binoculars

M18-I.R. (Fig. 36)

SU50 - Electronic-Passive I.R. (Note: AN/PVS-5 Night Vision Goggles)

Browpads

The browpads used in the study are shown in Figure 4. They are identified by type numerically (i.e., Type 1, 2, etc.) and further described in the following paragraphs.

Type 1 is a full browpad used with the M24 I.R. and M31 Periscopes and the M17C Rangefinder installed on the M60A1 Tank.

Type 2 is a full browpad used with the M50, M51 and M32 Periscopes on the M60A2 Tank and M60A1 Product Improved Tank, respectively.

Type 3 is a half-bar browpad designed for left-eye viewing. It is used with the daylight element of the M32 Periscope on the modified M60A1 Tank.

Type 4 is a half browpad. The design as shown is for right-eye viewing through the night-vision elements of the M32 and M36 Periscopes. However, designed in reverse—i.e., for left-eye viewing—it is used with the daylight element of the M36 Periscope and M105 Telescope for the modified fire-control in the M60A1 Tank.

Type 5 is a full-bar browpad. It is used with the M119 Telescope for the M551 Armor Airborne Reconnaissance Vehicle.

PROCEDURE

Data for the evaluation were gathered to generate information for evaluation; the assessment was planned to be conducted by the trial-and-error method. It investigated the degree of compatibility between the individual crewman and the test item, and/or between the test item and associated equipment. Since the browpad is the component which interfaces the crewman with the combat vehicle, the evaluation emphasized a single combination, consisting of the browpad, the crewman and the DH-132 Helmet. However, appropriate consideration was also given to the other representative types of associated equipment (e.g., goggles, binoculars, etc.)

When appropriate, preliminary field studies were conducted to substantiate information or to determine trends.

In interpreting the findings or results, appropriate consideration was given to the inherent characteristics of the associated equipment and the mission capability of the combat vehicle (tank) (i.e., stop-to-fire or fire-on-the-move capability).

DISCUSSION

Characteristics and Features of the DH-132 Helmet

The DH-132 Combat Vehicle Crewman (CVC) Helmet (Fig. 1) is composed of two major units: an outer hard protective module (often called the shell) that protects against bumps, and an innerliner (usually simply called the liner) that suspends the shell from the head and absorbs energy. The liner serves as a mount for the communications equipment (a microphone and two ear cups). The right ear cup mounts the microphone boom and houses the male connectors for receiving the microphone cable of the M25A1 Protective Mask with the DH-132 Helmet. The left ear cup, with an attaching communication cable, mounts and houses a three-position switch (monitor, radio and (lock) interphone).

The DH-132 Helmet has three manual adjustments for fit: (1) the ear cups rotate to position the ear seals properly; (2) a velcro nape tape (often merely called nape tape) adjusts the liner to the head's circumference; and (3) the adjustable chin strap has female snaps that fasten it to the liner's cheek flap. The leather portion of each cheek flap mounts the male portion of the directional snap fasteners. When properly adjusted and fastened, the chin strap stabilizes the helmet on the head, providing enough tension that the ear-cup seals fit around the ears snugly for acoustical attenuation.

The wearer adjusts the ear cup and nape tape on his head before assembling the shell to the liner. Then, after donning the helmet assembly, he fastens and adjusts the chin strap. He tightens the chin strap by pulling the web end protruding through the buckle. To release its tension, he pulls up on the leather tab.

To provide bump protection to the critical areas of the head, the helmet is normally worn in the attitude shown in Figure 1.

Fig. 1. Frontal view-DH-132

Design Analysis

This design analysis evaluates a helmet's inherent characteristics or features that affect its compatibility and interfacing with crewmen, equipment and task. These effects will be examined for functional areas in the following analysis.

By design, the DH-132 is intended to provide adequate communications, attenuate noise, and protect the wearer from bumps, while maintaining compatibility with required system interfaces.

Attenuation measurements of the DH-132 (CVC) Helmet System design discloses that its effectiveness as an attenuating device depends heavily on fastening and adjusting the chin strap properly. Unless the chin strap is adjusted and fastened, the DH-132's attenuation capability cannot be realized.

Fit

The helmet liner is provided in three sizes (small, medium and large).

The helmet shell is provided in two sizes (medium and large).

The helmet is fitted to the individual by adjusting the variable velcro nape to fit his head circumference, then adjusting the snap-fasten chin strap for stability.

The only way to fit ear cups is by rotating them. Once the nape tape and chin strap are adjusted, there is no way to adjust the ear cups' height or their fore-aft position.

These adjustments for fitting of the DH-132 Helmet do not appear adequate to accommodate the head's important but variable anthropometric features, such as head height, bitragion diameter (distance between the ears), ear length above tragion (length of ear above ear hole), tragion to the occiput (ear hole to back of head), and the circumference.

Comfort

A helmet's comfort depends on many variables, such as fit, weight, ventilation and pressure points.

While each of the helmet's three adjustments may accommodate the middle 90 percent of soldiers, it is often difficult to fit a helmet properly because the adjustments interact with each other. For example, the nape tape and chin strap seem to have opposite effects on fit. Fitting the liner to a soldier's head circumference means tightening the nape tape, which incidentally pulls the ear cups backward; yet there is no way to adjust the ear cups forward to their proper position (see Figure 19, indicator 4). Adjusting and fastening the chin strap pulls the helmet forward and downward, thus moving the ear cups downward. Depending on the wearer's head height and upper-ear length, the ear cups are sometimes so low that they actually fold the upper part of the wearer's ear down. Such a poor fit will obviously cause discomfort at the outset and, when soldiers must wear the helmet for long periods, it may well degrade performance in other ways.

Comfort is a subjective judgment; thus an evaluation of this aspect should be derived from a large number of troops wearing the helmet under normal operating conditions.

Some of the factors which affected comfort during our limited assessment include the pressure on the forehead (resulting in a waffle effect), pressure on the ears, chin strap irritation and heat. In addition, users had difficulty operating the snap fasteners, which are directional.

Compatibility and Interfacing: The Browpad, the Crewman and the DH-132 (CVC) Helmet Combination

During an assessment of compatibility–how elements in a system interact with each other–it is impossible to evaluate any item individually.

This assessment considers the interface of the man/helmet/browpad. Additionally, there is an interface relationship between the browpad and eyepiece, which depends on an adequate interface between the helmeted head and the browpad (e.g., the eye cannot reach its proper position on the eyepiece's optical axis unless the head is properly positioned in the browpad).

In assessing the browpad, crewman and helmet combination, three browpads, Type 1, 2 and 5 (Fig. 4) were selected. The Type 1 browpad was used in the field-of-view comparison study, Table 1. Type 2 and 5 browpads were selected because of their configuration, utilization and demonstration capability.

When evaluating the browpad within the designed station, the subject acting as crewman was properly adjusted and positioned so he could control and view the designated target or target area, and with the reticle in view.

An outline of the outer configuration of the Type 2 browpad on the gunner's face is shown by Figure 5. It illustrates how the head must be positioned in the browpad to obtain optical alignment for viewing with the M126 telescope, as installed in the M60A2 Tank. Figure 5 also shows the highest point the browpad reaches on the soldier's forehead.

A configuration outline of the Type 2 browpad on the gunner's face is also shown by indicator 3, Figure 6. It shows how the crewman must position his head in the browpad to use the M50 Periscope, as installed in the M60A2 Tank.

Indicators 1 and 2, Figure 6, illustrate the overlap between the Type 2 browpad area and the DH-132 Helmet, as worn in the normal attitude (Fig. 1).

When the crewman positions his head in the browpad as shown in Figure 5, his eye is in a position that will permit proper optical alignment (Fig. 7). However, if he positions the helmet on his head at its normal wear line (indicator 1, Fig. 6) his eye is vertically raised to a position (Fig. 8) where he cannot align his eye with the eyepiece. Figures 9, 10, and 11 illustrate that the Type 5 browpad causes these same difficulties.

Figures 5 through 8 clearly show that the tank crewman who wears the DH-132 Helmet in its normal attitude (Fig. 1), cannot position his head properly with the Type 2 and 5 browpads. To position his head and eyes so he can use the eyepiece (Figs. 5 and 7), he must readjust the DH-132 Helmet, tilting or rotating it toward the back of the head. The standard T-56 (CVC) Helmet also demands this same sort of readjustment.

TABLE 1

Angular Field of Measurement (Mils)
M31 Gunner Periscope - Type 1 Browpad

Condition	Description of Condition	Mean Field of View (Mils)	% Change
	Maximum FOV 8° + or 141.6 + Mils		
Condition I	(Control) Barehead against Browpad	137.47	- 3.0
Condition II	DH-132 - Liner against Browpad without Shell	111.42	-18.9
Condition III	DH-132 Shell and Liner Assembly against and in Browpad	62.78	-54.3
Condition IV	Standard T-56 Helmet against and in Browpad	33.58	-75.6
Condition V	DH-132 Helmet - (Shell and Liner Assembly) Tilted toward rear of head	140.48[a]	+2.2
Condition VI	Standard T-56 Helmet Tilted toward rear of head	139.68[a]	+1.6

[a]Under conditions V and VI, field of view was larger—by 2.2 and 1.6 percent respectively—than in condition I. This improvement may be due to learning during each subject's 120 trials. It may well be that the subjects also made a greater effort to compensate for the bulk on their heads.

Fig. 2. Frontal view-DH-132 helmet-chinstrap unfastened.

Fig. 3. Frontal view T56 helmet.

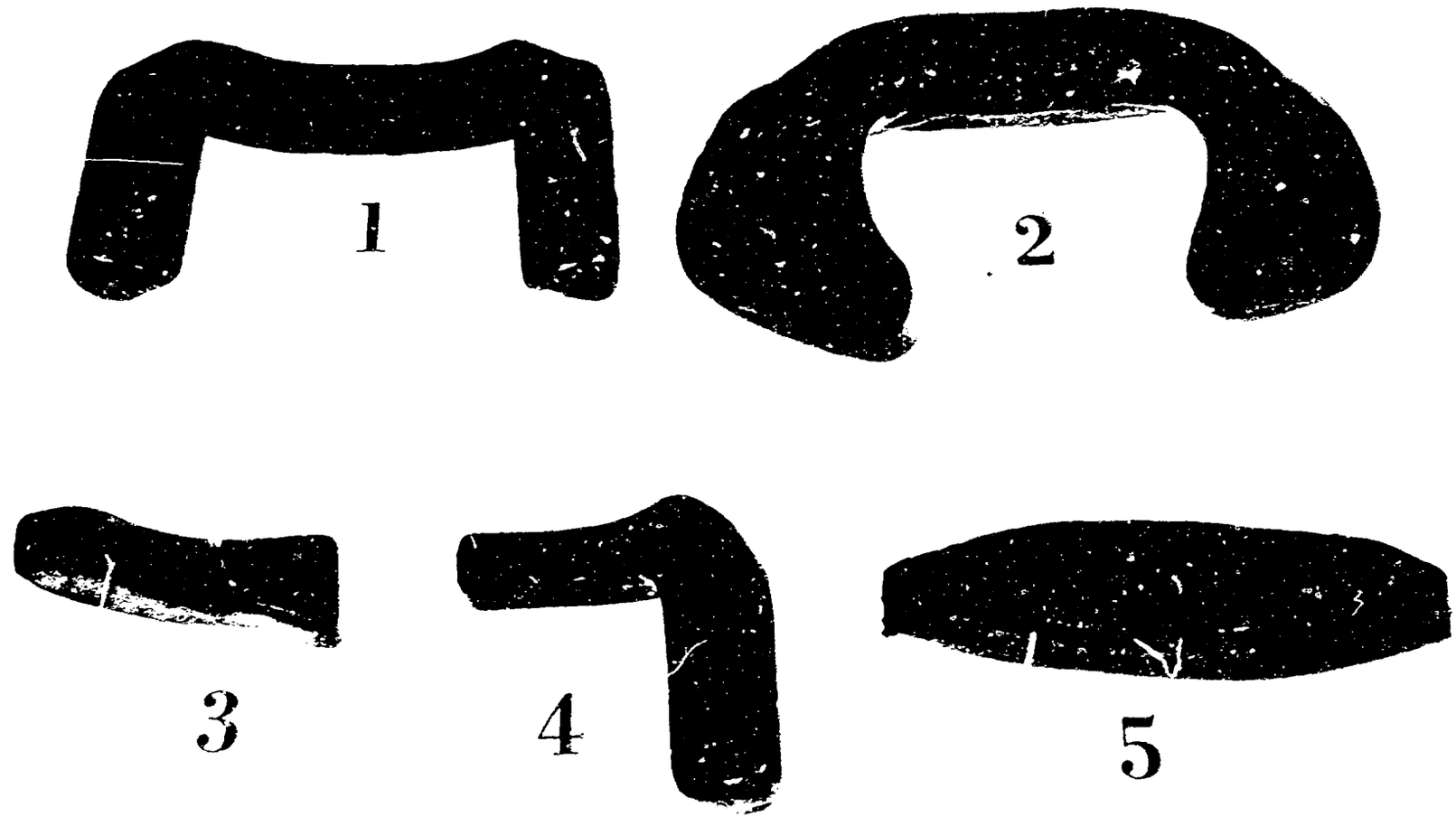


Fig. 4. Five types of browpads currently used in tank-type vehicles.

Fig. 5. Forehead and facial contact area, full browpad type 2 and DH-132 helmet (1-2) helmet normal wearline. (3) browpad facial position, viewing M50 periscope and (4) helmet when tilted back.

Fig. 7. Eye position - addressing full browpad, type 2, for viewing with M50 and M51 periscope with DH-132 helmet tilted back.

Fig. 9. Frontal view - (1. normal wear-line of DH-132 helmet and (2) DH-132 wear-line when addressing full bar browpad, type 5, when viewing through M19 telescope

Fig. 10. Eye position - addressing full bar browpad, type 5, for viewing with M119 telescope, helmet tilted back.

Unfortunately, both helmets give less protection when worn in these unintended positions. When either helmet is tilted rearward (or rotated rearward), the crewman's forehead becomes more vulnerable, because it has less protection from bumps.

As an alternative, the DH-132 Helmet can be held against—or even pressed into—either type of browpad as a makeshift way of aligning eyepiece and eye (Figs. 12, 19, 21 and 23). However, this position readily transmits vehicle vibration and shock to the head. Reducing head stability can significantly degrade fire-on-the-move capability with the M60A2 Tank and the M60A1 (Product Improved) Tank. Thus the most serious disadvantage of placing the helmet firmly against (or in) the browpad is that the browpad no longer functions as an energy-absorbing device.

Furthermore, even holding the helmet against or in the browpad does not bring the crewman's eye to the normal, intended position for the particular optic, so that the field of view is narrowed. In most cases, the browpad's fore-aft adjustment, designed as an eye-relief adjustment, cannot accommodate the necessary range of individual head and helmet stand-off combinations.

Another aspect worth considering is the time lost in going from a normal helmet-wear attitude to an operational helmet attitude—that is, from full protection, when properly worn, to decreased protection when rotating the helmet backward to use the eyepiece. The time lost in changing helmet positions can decrease firing times appreciably.

Compatibility with Representative-Type Combat Vehicles (Tank Type)

Using illustrations and subjective responses to assess the degree of compatibility or interfacing qualities in the browpad/crewman/helmet combination gives results that must be reconciled with total-system requirements where all these items are related to the individual crewman's tasks and to the system's operational mission requirements.

The M60A2, the M60A1 (Standard and Modified), M60A1 (Product Improved) Tanks and the M551 Armored Reconnaissance Airborne Assault Vehicle (ARAAV) were selected as representative-type vehicles, for assessing the DH-132 Helmet's relative compatibility and interfacing with combat vehicles.

M60A2 Tank

The M60A2 Tank has two significant characteristics that differ from any other tank the U. S. Army has fielded. It has a stabilized gun-and-turret system, and a target-designating system operated by the commander. These two features give the M60A2 Tank a highly desired fire-on-the-move capability.

The purpose of the target-designating system is to allow commanders to position the turret so that the target he detects, acquires, and verbally announces will appear within the gunner's field of view (M50 Periscope). This system significantly reduces the time lost between when the commander detects and identifies a target, and when the gunner lays the weapon, thus correspondingly reducing the amount of time required to fire the first round on target, regardless of whether the mission is stop-to-fire or fire-on-the-move.

To protect the gunner from noise and bumps during a fire-on-the-move mission, he would be required to wear the DH-132 Helmet in the normal attitude with chin strap fastened (Fig. 1) or the T-56 Helmet in the normal attitude (Fig. 3).

Whether the gunner identifies the target through the viewer (unity-power window) or the eyepiece of the M50 Periscope, he has two ways of positioning himself in front of the browpad: (1) face the browpad on the M50 Periscope in the same way he looks through the M126 Telescope (Fig. 12), maintaining bump and acoustical protection, but sacrificing some field of view, head stability, and full use of the browpad; or (2) turn the DH-132 Helmet so he can face the browpad as shown in Figure 13, obtaining the full view, head stability, and full use of the browpad--but sacrificing the forehead's bump protection, and prolonging preparation time before firing.

If the gunner chooses the second method, he must readjust the DH-132 Helmet, which requires four additional steps: (1) release the chin-strap tension by pulling (lifting up) the leather strap; (2) tilt the helmet backward on his head; (3) readjust the ear cups (that is, change the position of the cheek flaps, which determine ear-cup position as the helmet is tilted back; see distance from indicator 2 to indicator 4, Fig. 6); and (4) readjust acoustical protection by pulling on the web tab that protrudes through the buckle to tighten it. After readjustment, the helmet's position on the head would be approximately as shown in Figure 26, forfeiting forehead-bump protection. The additional time required to readjust the DH-132 Helmet would very likely offset the primary advantage of the target-designate system; it would probably take at least as much time from the commander's target detection to target identification and lay by the gunner.

The commander would also have to perform this same basic readjustment when using his periscope. While he could preadjust the periscope when he intended to fight, there are still drawbacks, since the tank, and consequently his forehead, would become vulnerable to bumps.

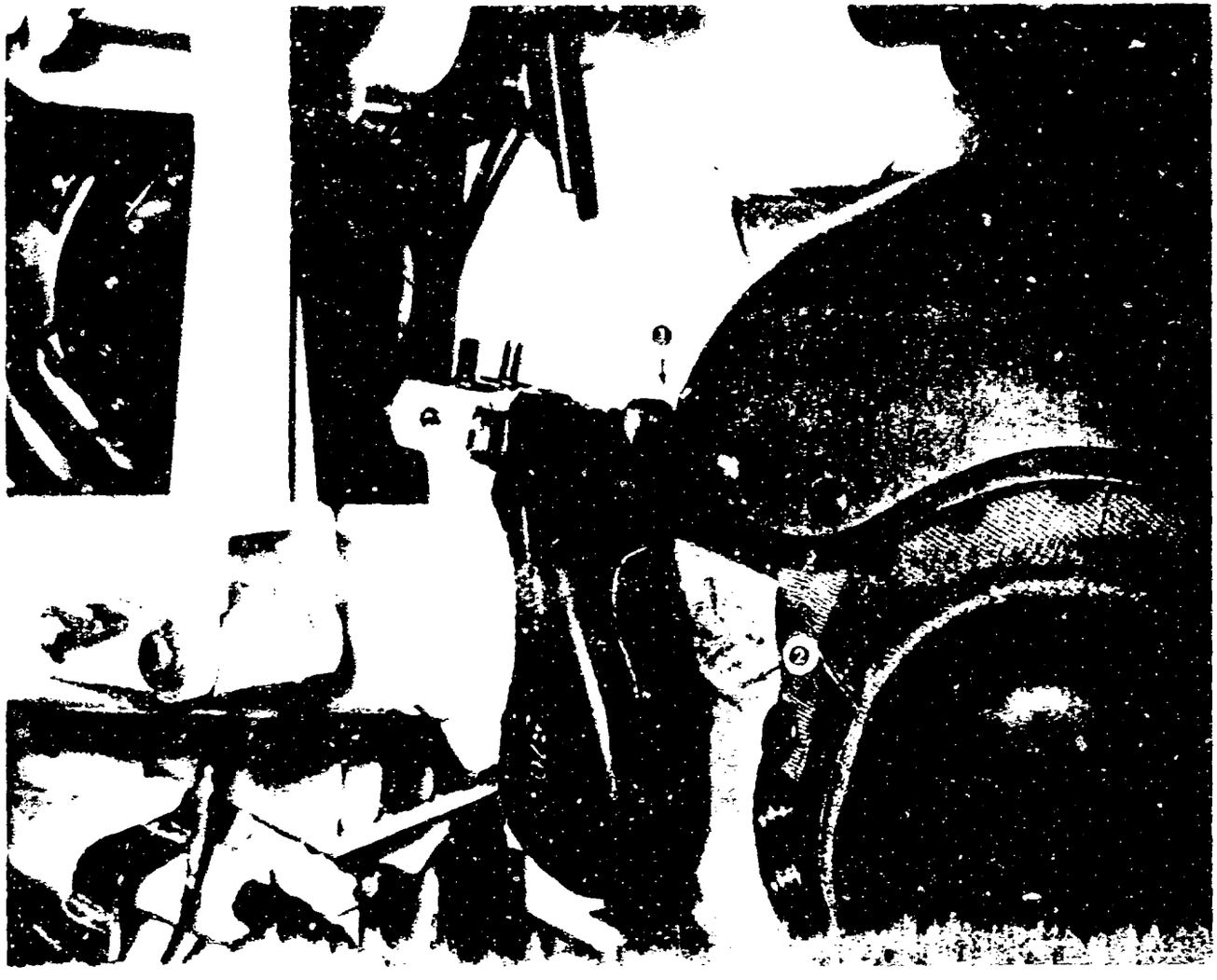
Figure 12. shows the gunner using the browpad on the M126 Telescope while wearing the DH-132 Helmet in its normal attitude. Indicator 1 shows the helmet's position against and in the browpad; indicator 2 highlights the crewman's eye position, and distance between the peripheral portion of the browpad and the cheek flap.

Indicators 2 and 3, Figure 13, illustrate how helmet shell and cheek flaps change their relative positions when the DH-132 Helmet is adjusted. It can be noted that the front edge of the helmet now protrudes above the browpad, the peripheral portions of the browpad now touch the snap-fastener support; i.e., mounts to the cheek flap and the outer canthus of the eye have moved into the browpad, as did the forehead.

Figure 14 shows the right ear-cup-mounted microphone catching in the browpad, as the gunner removes his head from the M50 Periscope and turns his head left to view panels. A padded footstep located behind the gunner's head, for ingress and egress, restricts rearward head motion.

In review, it is indicated that accommodating the browpads of the M60A2 Tank, means that the DH-132 Helmet must be readjusted, compromising bump protection to the forehead and risking possible delay of system performance from time of target detection to first round on target.

As compared with the T-56 Standard Helmet, the primary problem still exists; either helmet must be tilted back to address the browpad properly. However, to maintain its acoustical-attentuation capability, the DH-132 Helmet's chin strap must be readjusted when the helmet is rotated.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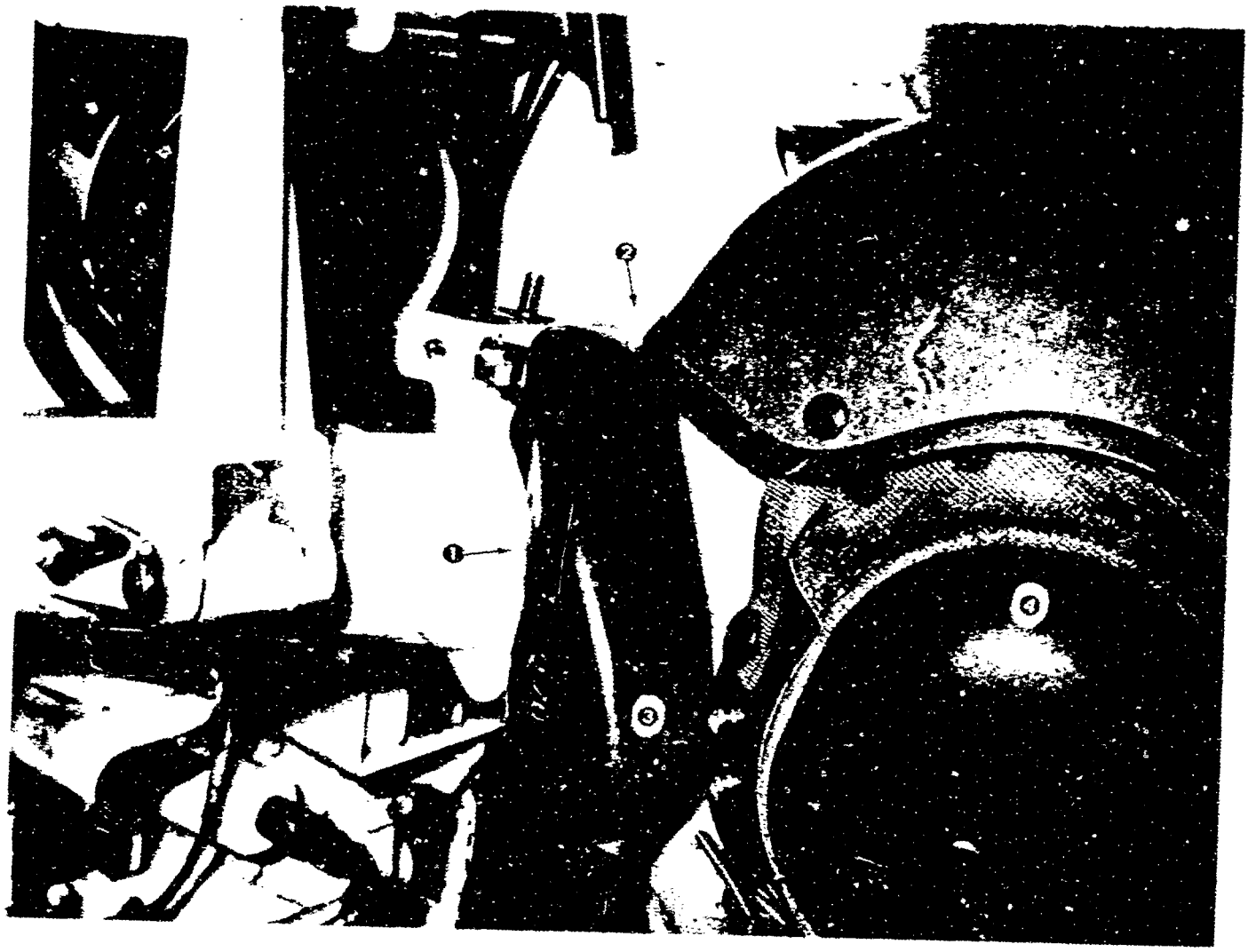
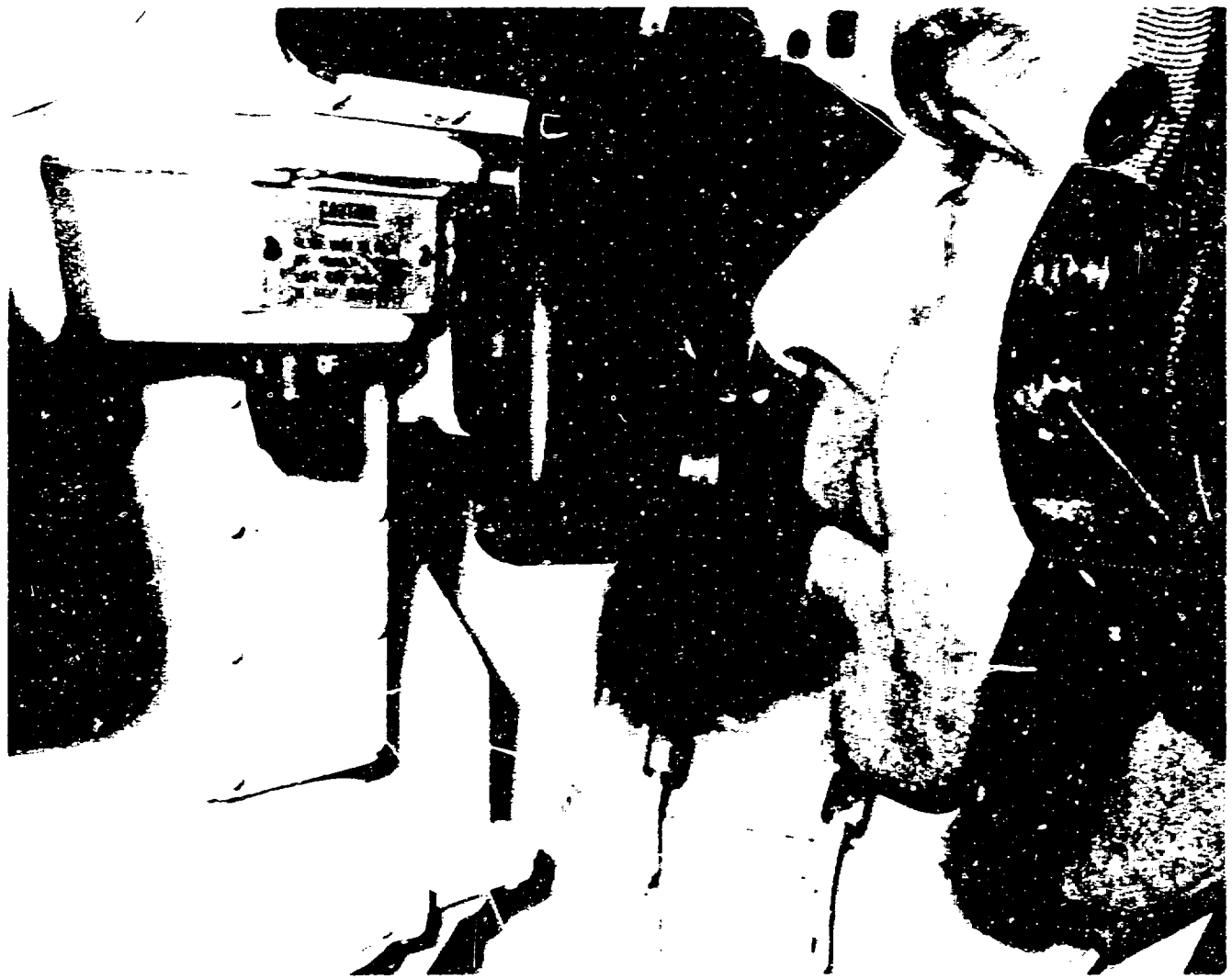


Fig. 13. M60A2 tank - M126 telescope, full browpad, type 2, with DH-132 helmet tilted back, forehead against browpad, right eye viewing



M60A1 (Product Improved) Tank

The M60A1 (Product Improved) Tank also has a fire-on-the-move capability, which requires the Type 2 full browpad. Figure 15 shows a gunner's view of its fire control (gunner station) with browpads as well as surrounding associated components.

For a crewman to properly use the full browpad of the day element (center eyepiece), the night-vision browpad (indicated) must be hinged upward (Fig. 17).

Figure 16 shows the gunner with the DH-132 Helmet readjusted from normal position so he can address the full browpad of the day element. Indicator 1 points out the front of the helmet on top of the browpad, and indicator 2 shows distance between helmet shell and back of neck when tilted backward.

Figure 17 shows the gunner addressing the same browpad as in Figure 16, with the standard T-56 Helmet tilted back. In Figure 17, indicators 1 and 2, shows the helmet on top of the browpad, and the helmet's closeness to the back of the neck.

The M60A1 (Product Improved) Tank does not have a target-designate system as yet. However, to address the browpads properly, the DH-132 Helmet must be adjusted as in the M60A2 Tank.

M60A1 Tank (Standard Modified)

Figure 18 shows the gunner's-station view of the optical sights of the M60A1 Tank, with their respective browpads mounted.

Figure 19 shows the gunner using the half-bar browpad, Type 3, with the DH-132 Helmet in the normal-wear position. Indicator 1 shows the browpad's position against the helmet. Indicator 2 illustrates the distance between a gunner's eye and the day element's eyepiece. (Half browpad for the M105 Telescope has been removed for this illustration.)

Figure 20 shows the gunner addressing the same browpad as in Figure 19, but with the DH-132 Helmet tilted backward. Indicator 1 shows the helmet over the top of the browpad. Indicator 2 shows the tilted helmet against the neck. Indicator 3 shows how tilting allows moving the gunner's eye closer to the eyepiece (compare indicator 2, Fig. 19). These indicators (Figs. 19 and 20) also demonstrate that the longitudinal adjustment of the browpad must be fully forward in either case.

Figure 21 shows how a gunner, wearing the DH-132 Helmet in normal attitude, positioned his head against the half browpad, Type 4 (left-eye viewing), as installed on the M105 Telescope. Because the M105 Telescope requires a clear-eye distance of only .970 inches, even the DH-132's short stand-off distance allows him to reach the proper eye position. Indicators 1 and 2 point out the position of the browpad against the helmet, and against the snap-fastener support on the cheek flaps.

Figure 22 shows the gunner addressing the same browpad as in Figure 21, but with the DH-132 Helmet tilted rearward. Indicator 1 shows the helmet touches the top of the browpad, and indicator 3 reveals that the peripheral facial portion of the browpad is in full contact with the snap-fastener support and the left ear cup. Indicator 2 shows where the helmet and liner touch the back of the neck.

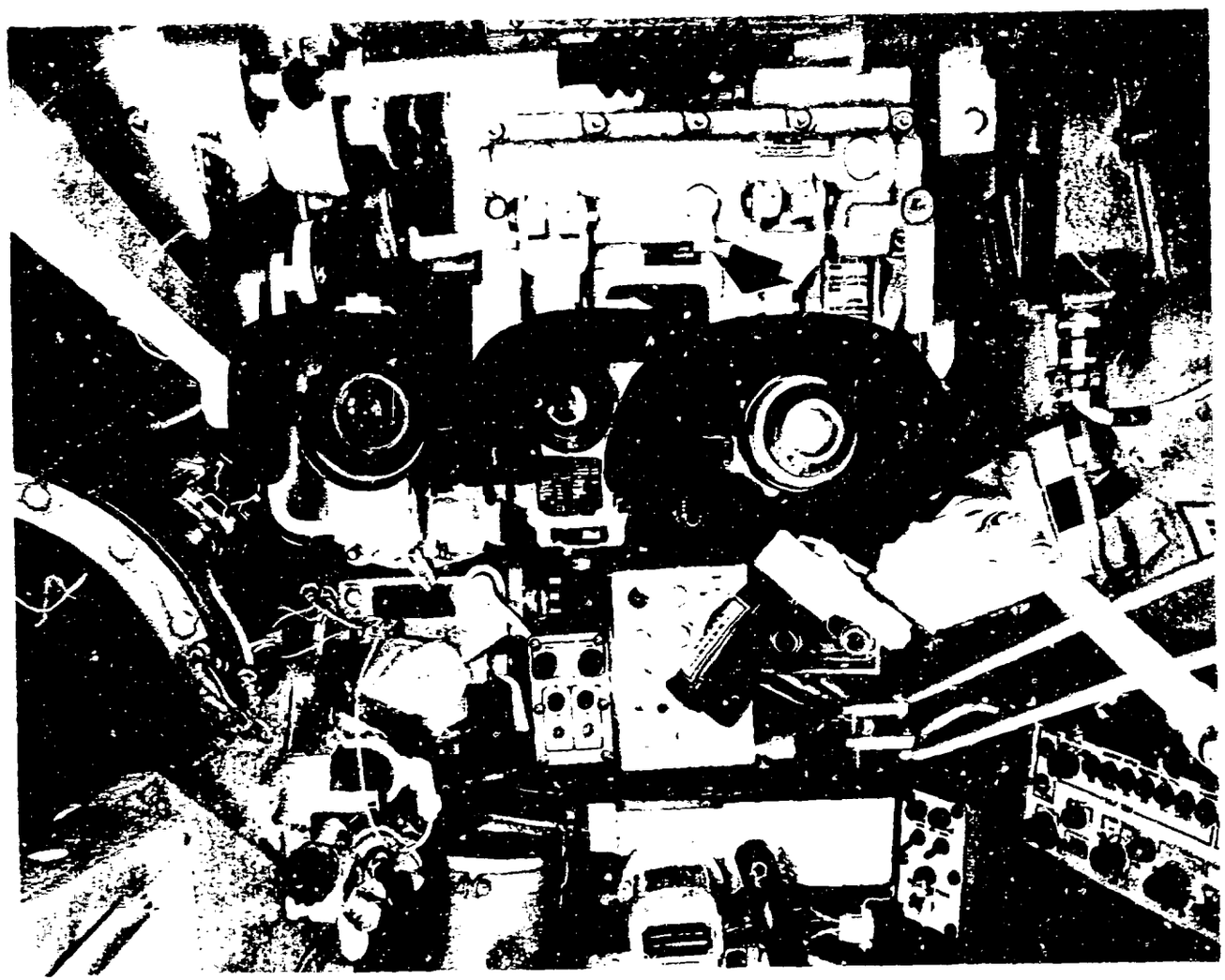


Fig. 15. M60A1 tank (PI) product improved — Gunner's fire control (left to right) M105 telescope, with half browpad, type 4, left eye viewing; M36 periscope with full browpads type 2, for left and right eye viewing.

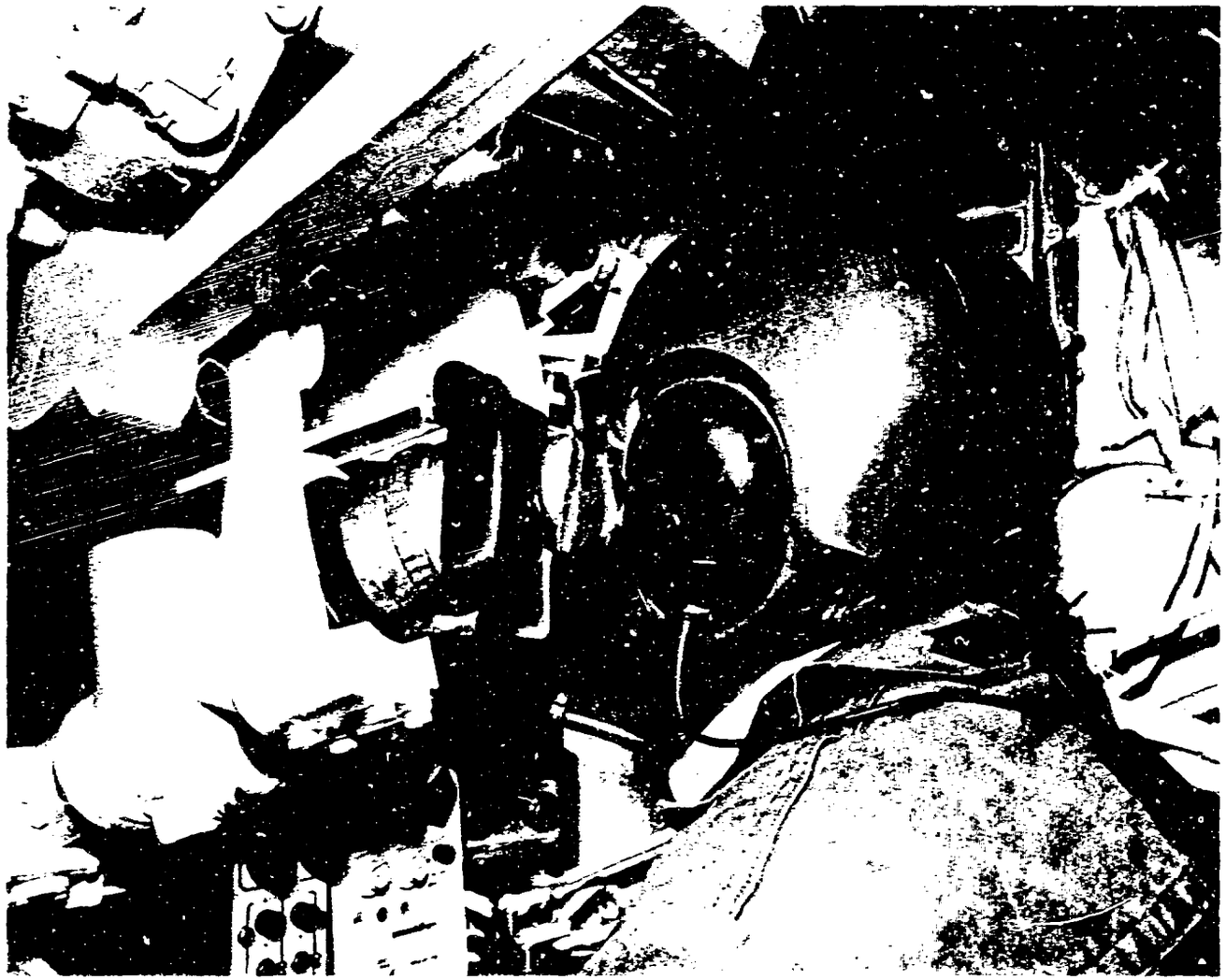


Fig. 16. M60A1 tank (PI) gunner viewing with M36 periscope day element, full browpad, type 2, left eye viewing forehead against browpad; DH-132 helmet tilted back.

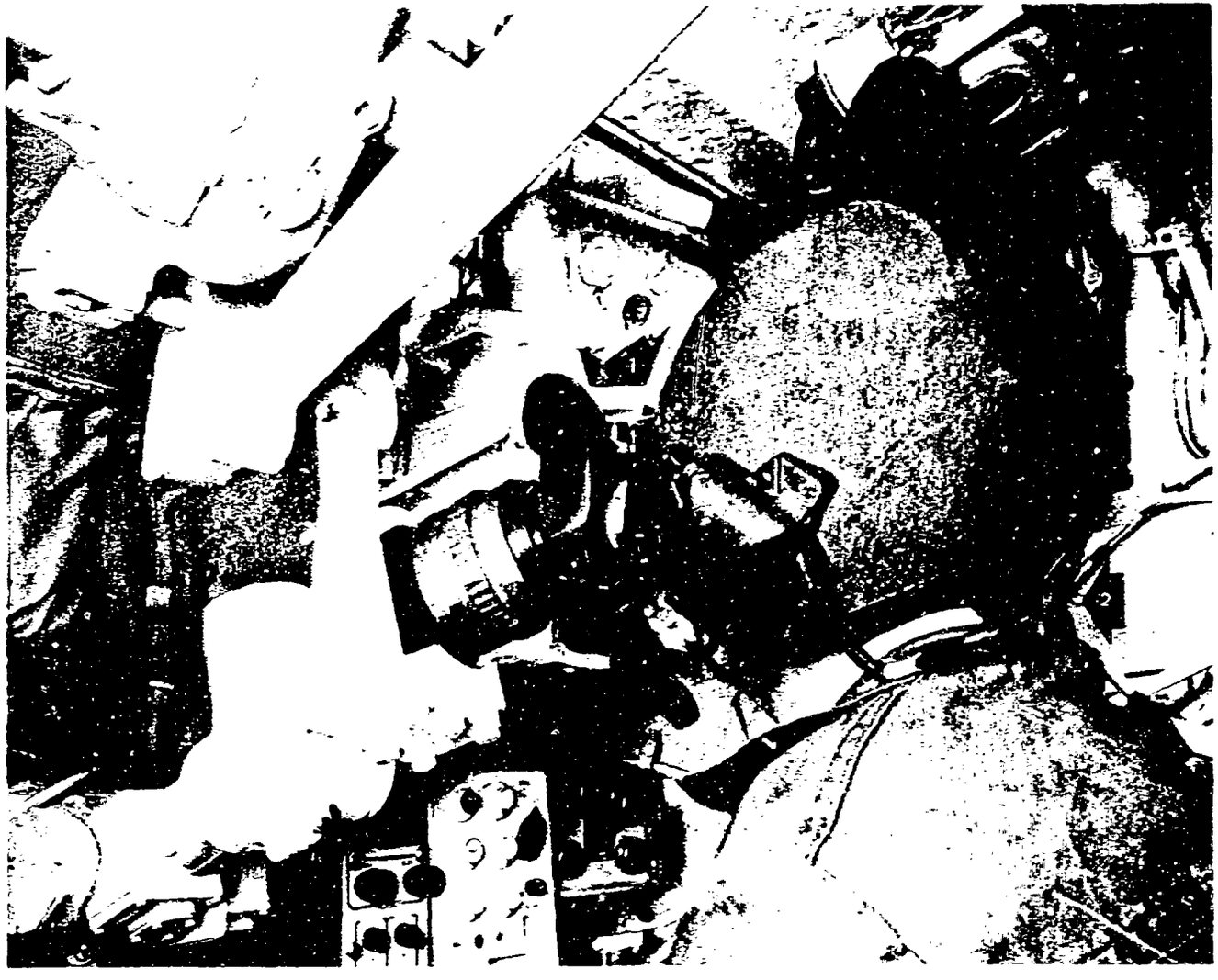


Fig. 17. M60A1 tank (PI) gunner viewing with M36 periscope day element full browpad, type 2, left eye viewing forehead against browpad, T56 helmet tilted back.

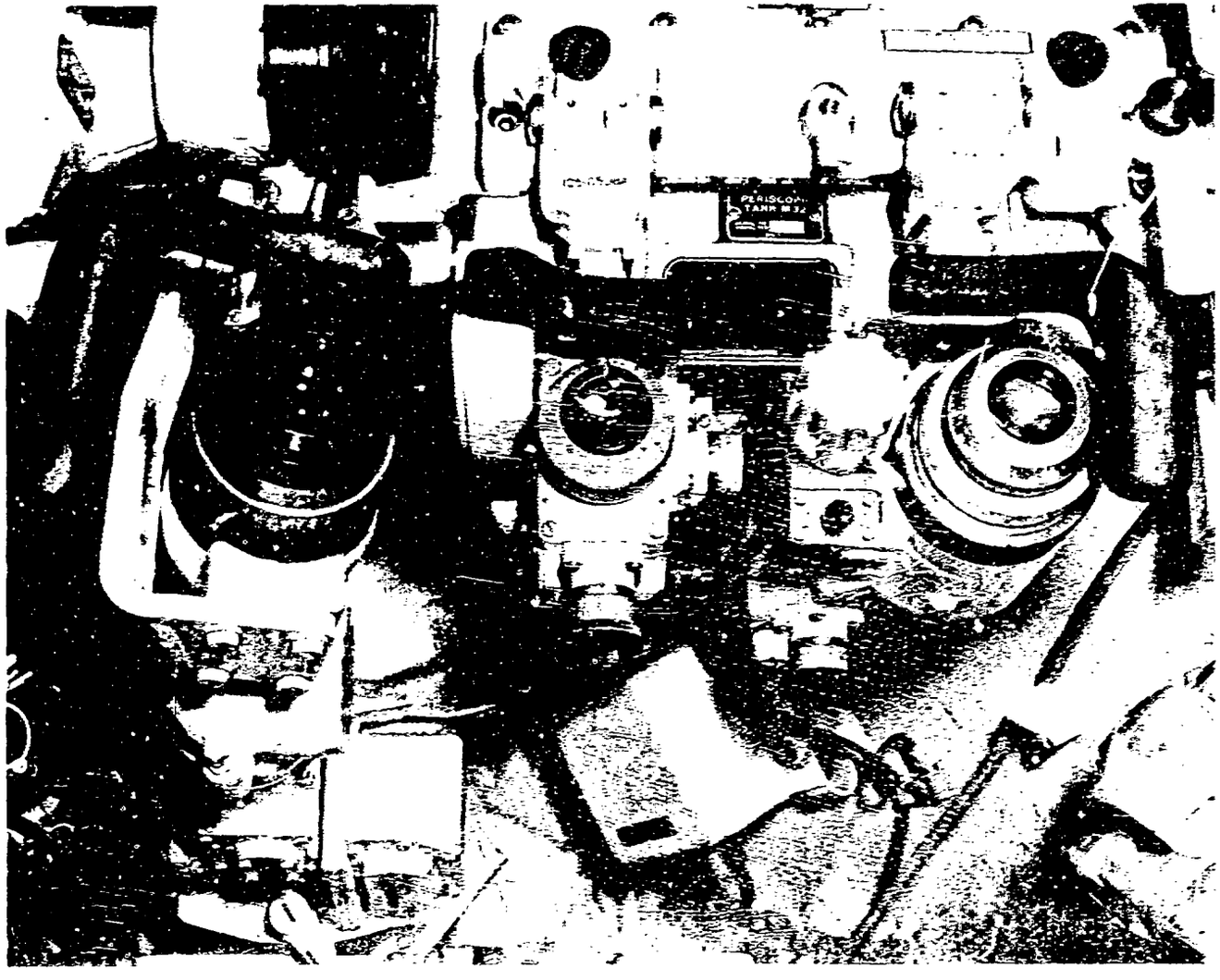


Fig. 18. M60A1 tank (modified)—gunner's fire control. (left to right) M105 telescope, with half bar browsad type 3 (left eye viewing) and half crowsfoot, type 4, right eye viewing.

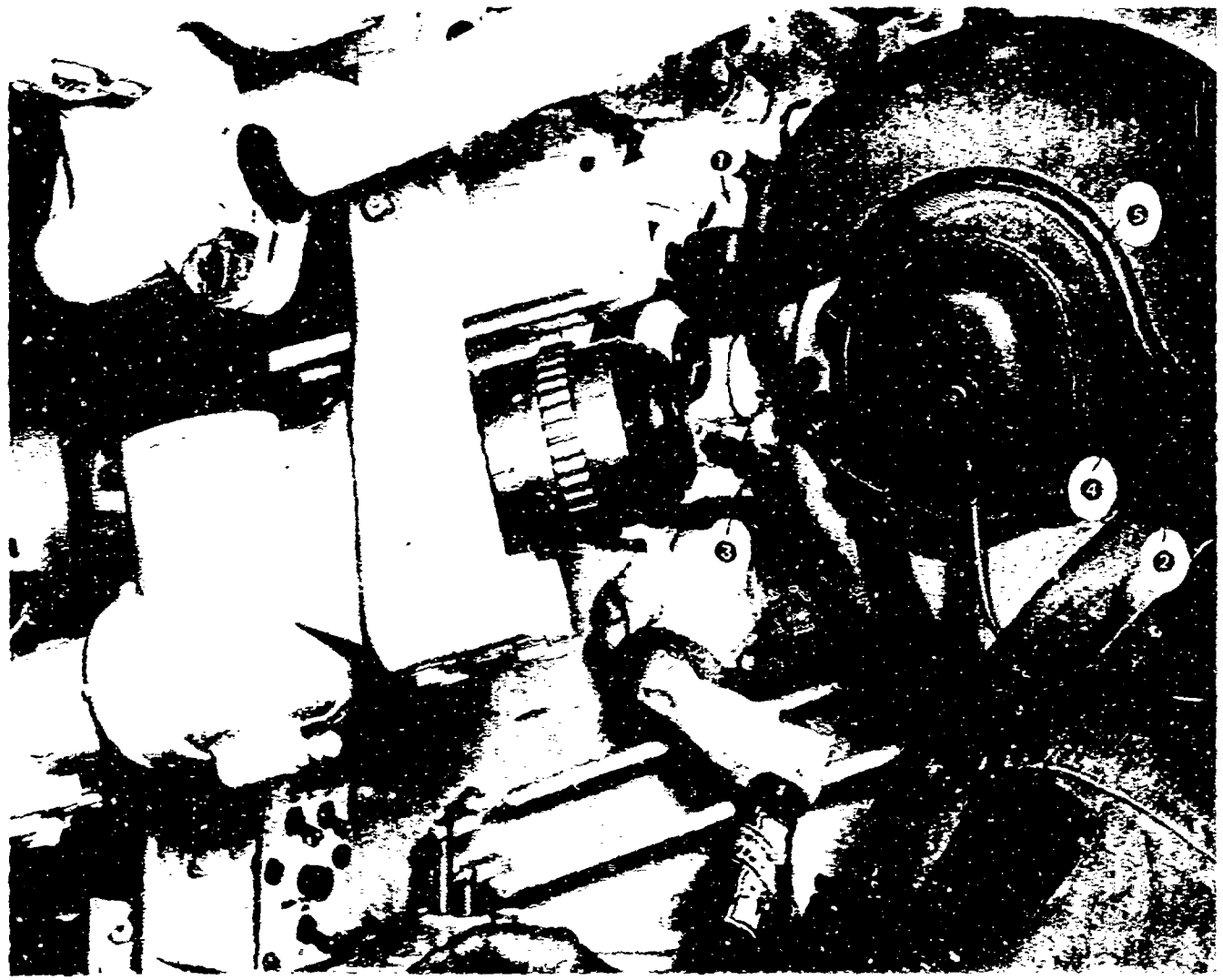


Fig. 9. M50A1 (modified) gunner viewing with day element DH-132 helmet positioned against half bar type 3 browpad.

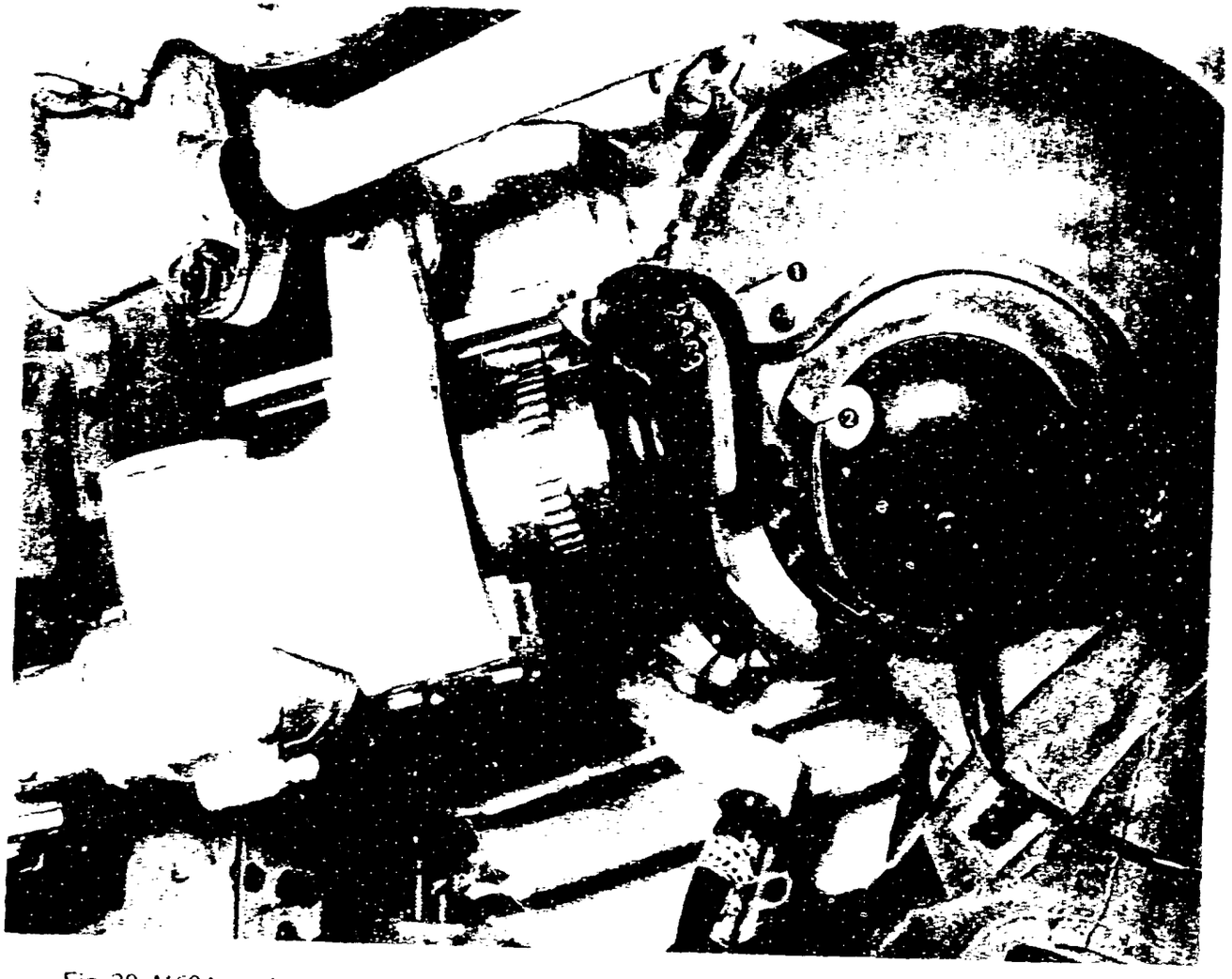


Fig. 20. M60A1 tank (modified), gunner viewing with day periscope, forehead against
[illegible] Size 3, DH-132 helmet tilted back

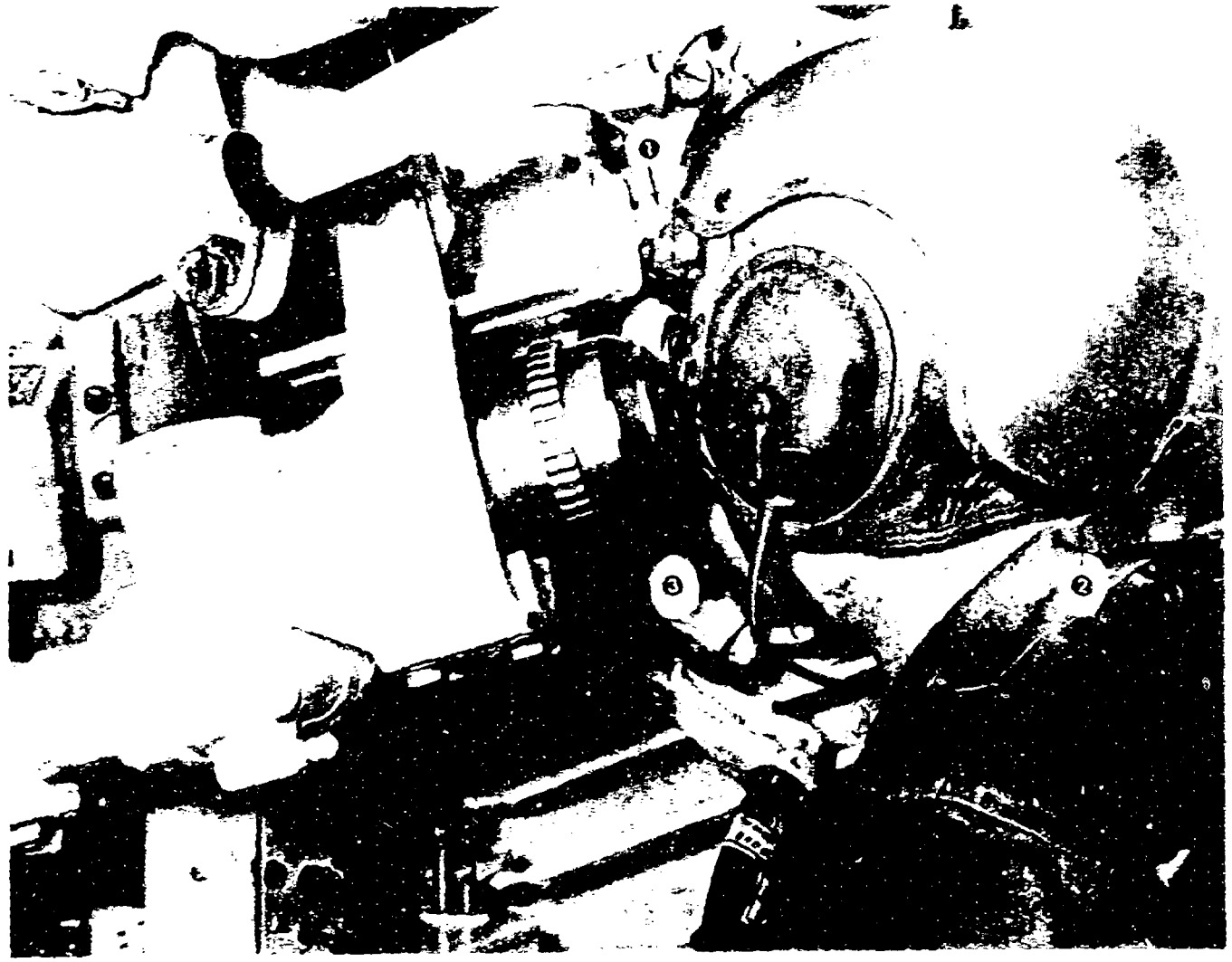


Fig. 21. M6[illegible] gunner viewing with M105 telescope, half brownout type 4, left eye viewing DH-132 helmet against bright

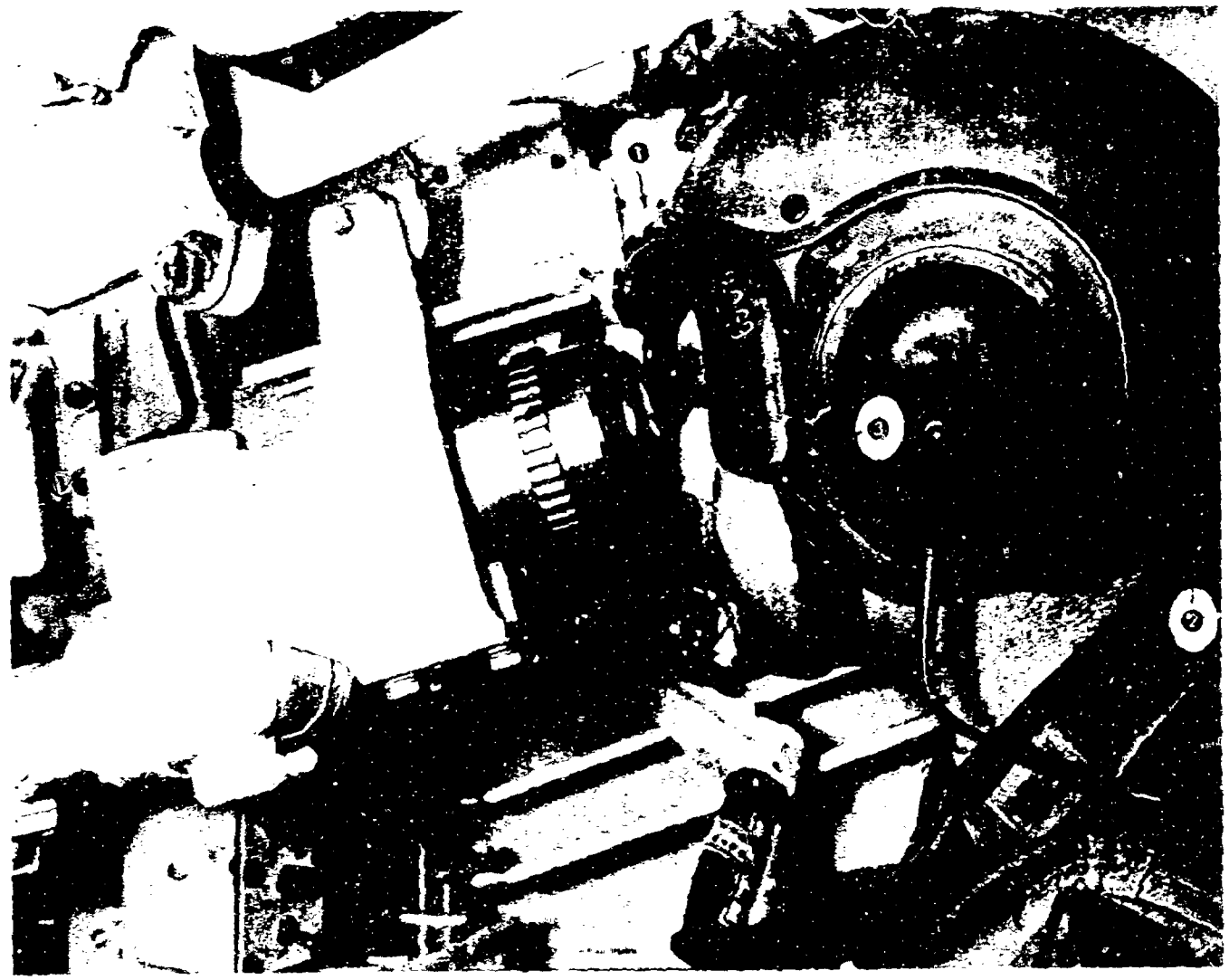


Fig. 22. M60A1 tank–gunner viewing with M105 telescope, half browpad type 4, left eye viewing, forehead against browpad DH-132 helmet tilted back.

In Figure 23, a commander wearing DH-132 Helmet in the normal attitude, addresses the full browpad, Type 1, mounted on the M17 Rangefinder. Indicator 1 discloses that the helmet presses against and into the browpad. Indicator 2 shows the over-all relationship between the helmet and back of neck. Indicator 3 points out the distance between the body of the rangefinder and the commander's nose.

Figure 24 shows the same view as Figure 23, except that the helmet is tilted rearward. Indicators 1, 2 and 3, respectively, show the helmet is on top of the browpad, that the helmet shell and liner touch the back of the neck, and that the distance between the commander's nose and the body of the rangefinder is reduced.

Figures 25 and 26 compare the different clearances for the standard T-56 and DH-132 Helmets, worn in the tilted position, with the M17 Rangefinder. Indicator 1 shows the head clearance between helmets and rangefinder. Indicator 2 shows that the DH-132 provides a larger clearance than the T-56.

M551 Armored Reconnaissance Airborne Assault Vehicle (ARAAV)

In the M551 ARAAV, the gunner's fire-control sighting equipment comprises the M119 Telescope and M44 Periscope (night vision), both with full-bar browpad, Type 5 (Fig. 4).

Figure 27 shows the gunner wearing the DH-132 Helmet in normal attitude, addressing the full-bar browpad mounted to the M119 Telescope with the DH-132 Helmet worn in normal attitude. In Figure 28, the helmet is tilted toward the rear of the head. Indicator 1 points out the relative positions of helmet front and browpad. Indicator 2 shows how the distance between back of helmet and back of neck decreases when the gunner tilts the helmet.

With an eye-relief distance of 1.30 inches, the M119's browpad can be adjusted for proper eye position when helmet is positioned against and in the browpad. However, this position is dangerous; the gunner could be injured seriously if the main weapon were fired while his helmet was against the browpad (Fig. 27). This is because of the combined forces of tank motion and recoil from firing conventional ammunition in the main weapon.

Figures 29 and 30 show the M551 gunner addressing the full-bar browpad, Type 5, mounted to the M44 Periscope. In Figure 29 he is wearing the DH-132 Helmet in the normal attitude; in Figure 30, it is tilted rearward on the head. (Browpad on M119 Telescope has been removed.) Indicator 1 shows the distance between helmet front and browpad. Tilting the helmet backward from its normal position decreases the space between the back of the helmet and the back of the neck, as indicator 2 illustrates.

When the gunner positions his right eye to view through the M44 Periscope, the microphone boom that is mounted to the right ear cup touches the traversing-gear housing. Despite trying several positions of the microphone boom, in an attempt to eliminate this interference while still maintaining a suitable lip-to-microphone position, no satisfactory position could be found. This interference appeared significant because it makes it harder for the gunner to maintain proper eye alignment.

Fig. 23 M60A1 tank, range finder M17 full browpad, type 1, helmet against browpad.

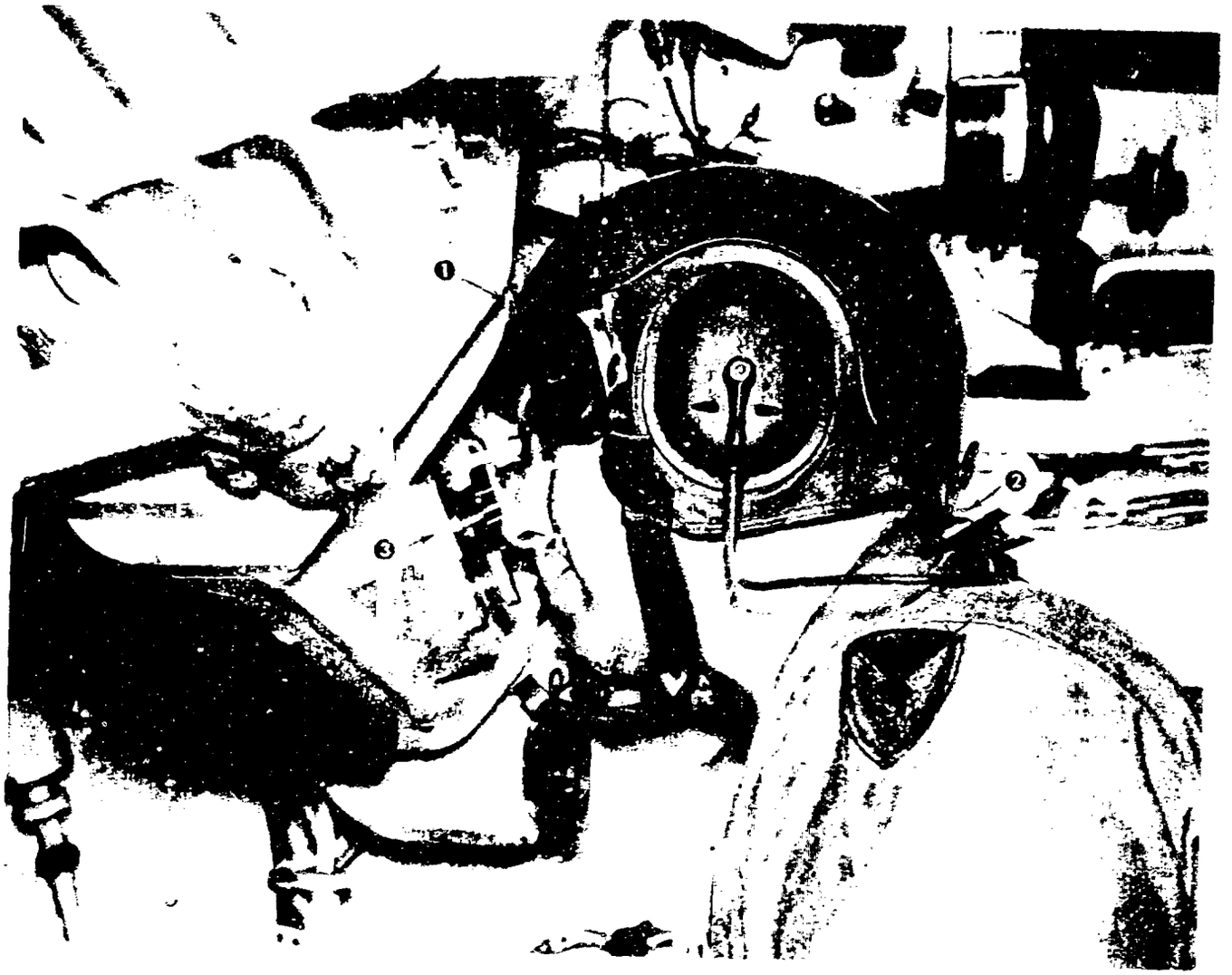


Fig. 24. M60A1 tank– range finder M17, full browpad, type 1, forehead against browpad, DH-132 helmet tilted back.

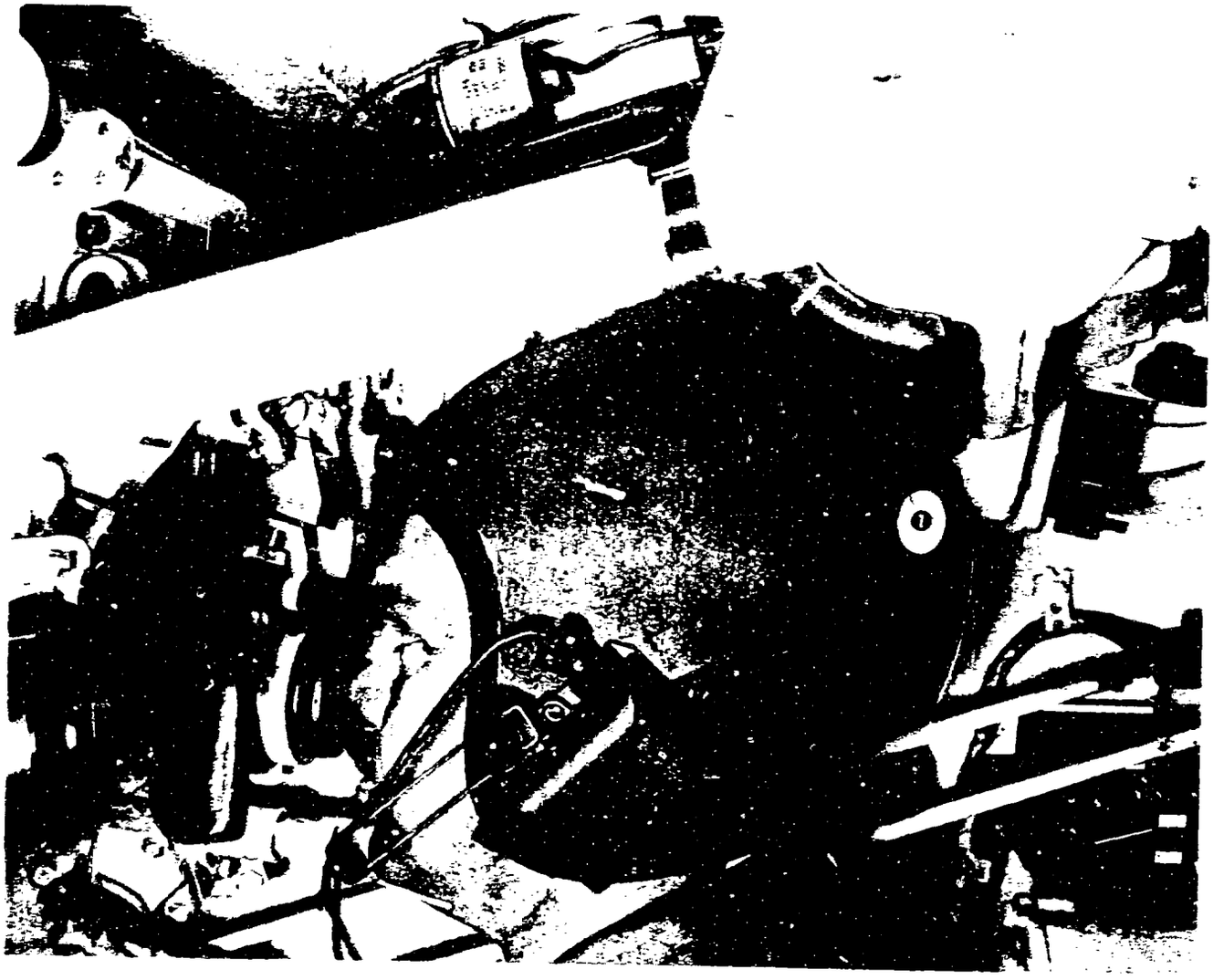


Fig. 25. M60A1 tank– gunner wearing T-56 helmet, range finder M17 interferes with rearward head motion.

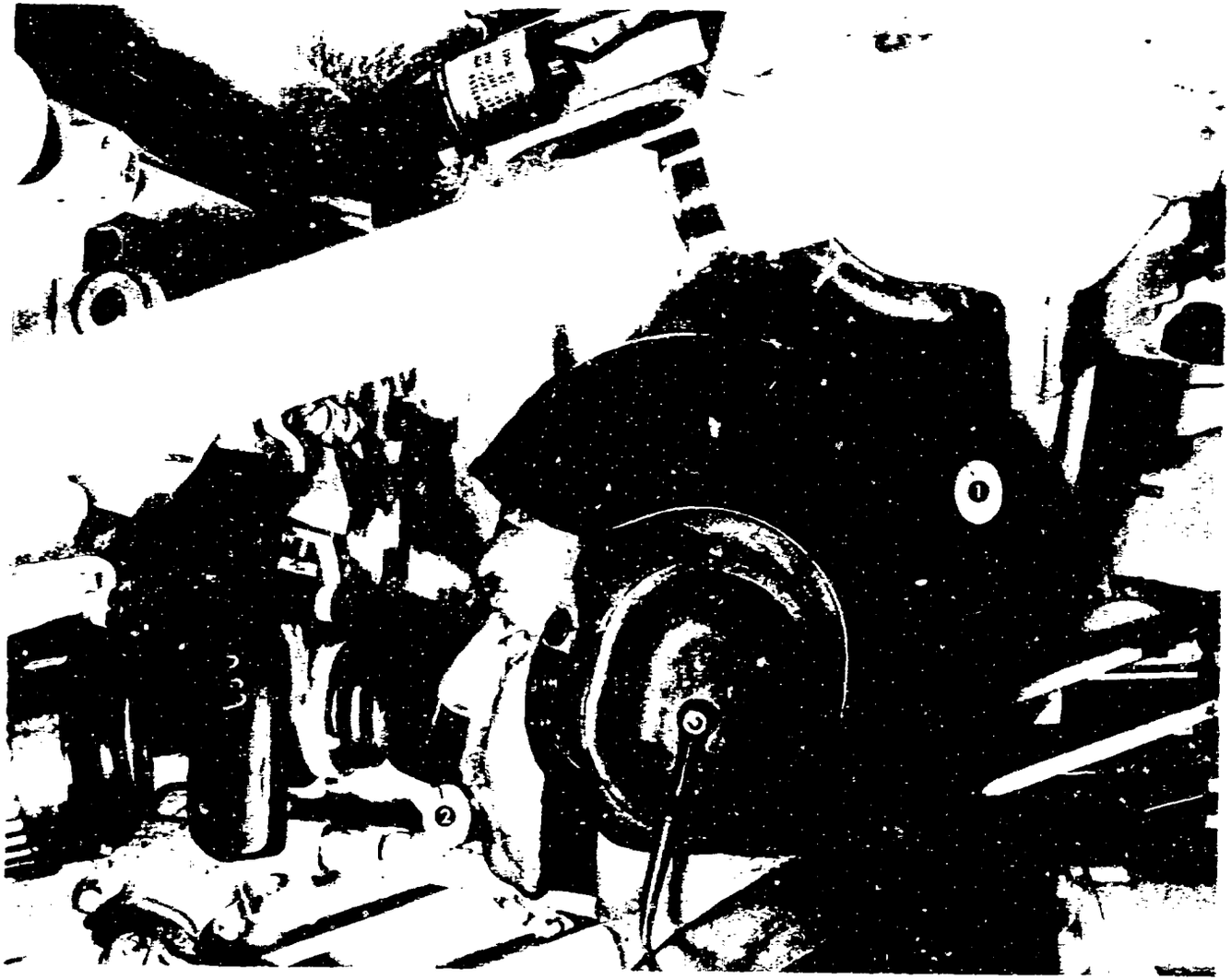


Fig. 26. M60A1 tank– gunner wearing DH-132 helmet, range finder interferes with rearward head motion.

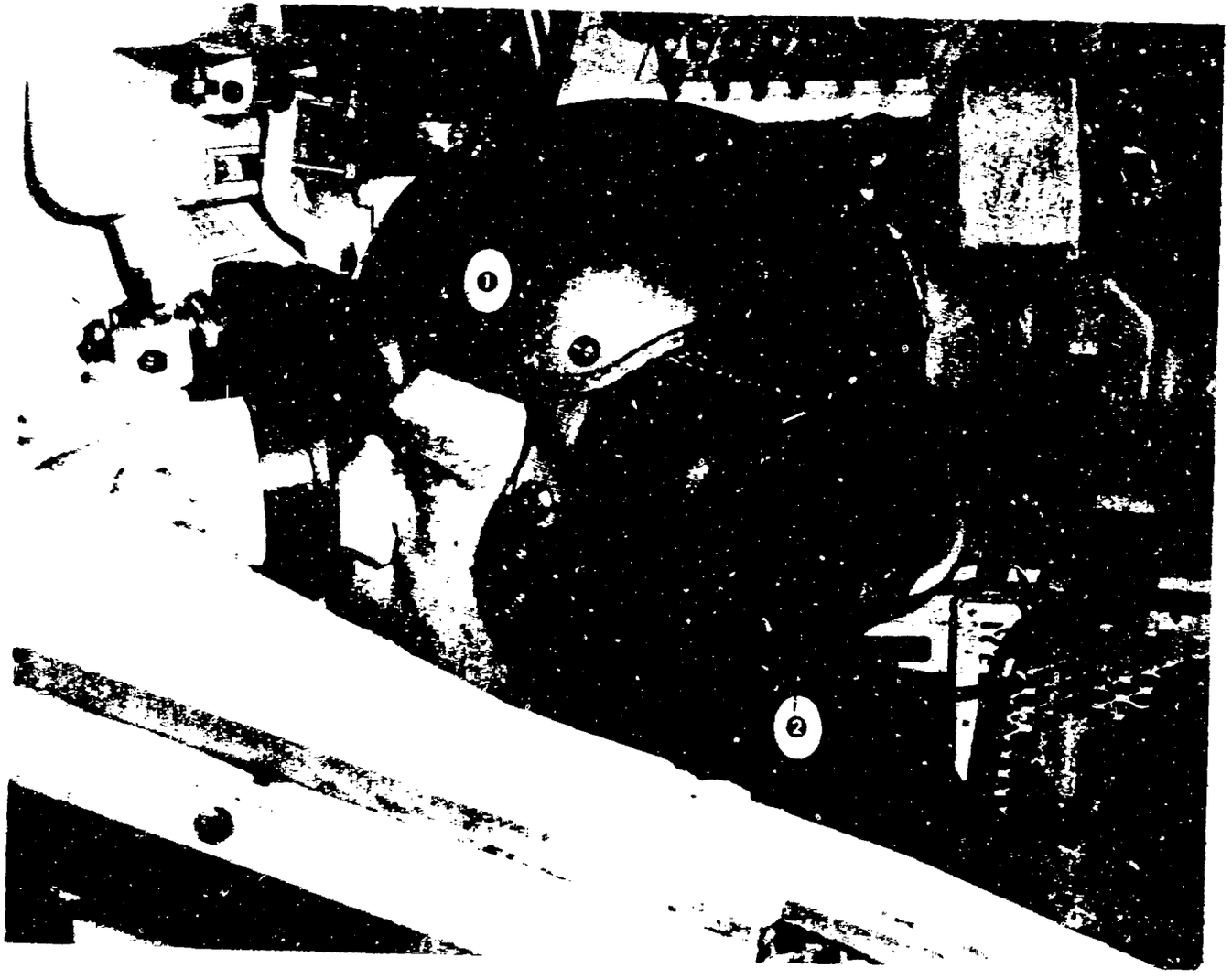


Fig. 27. M551 (Sheridan) gunner viewing with M119 telescope, full bar browpad, type 5, DH-132 helmet against browpad

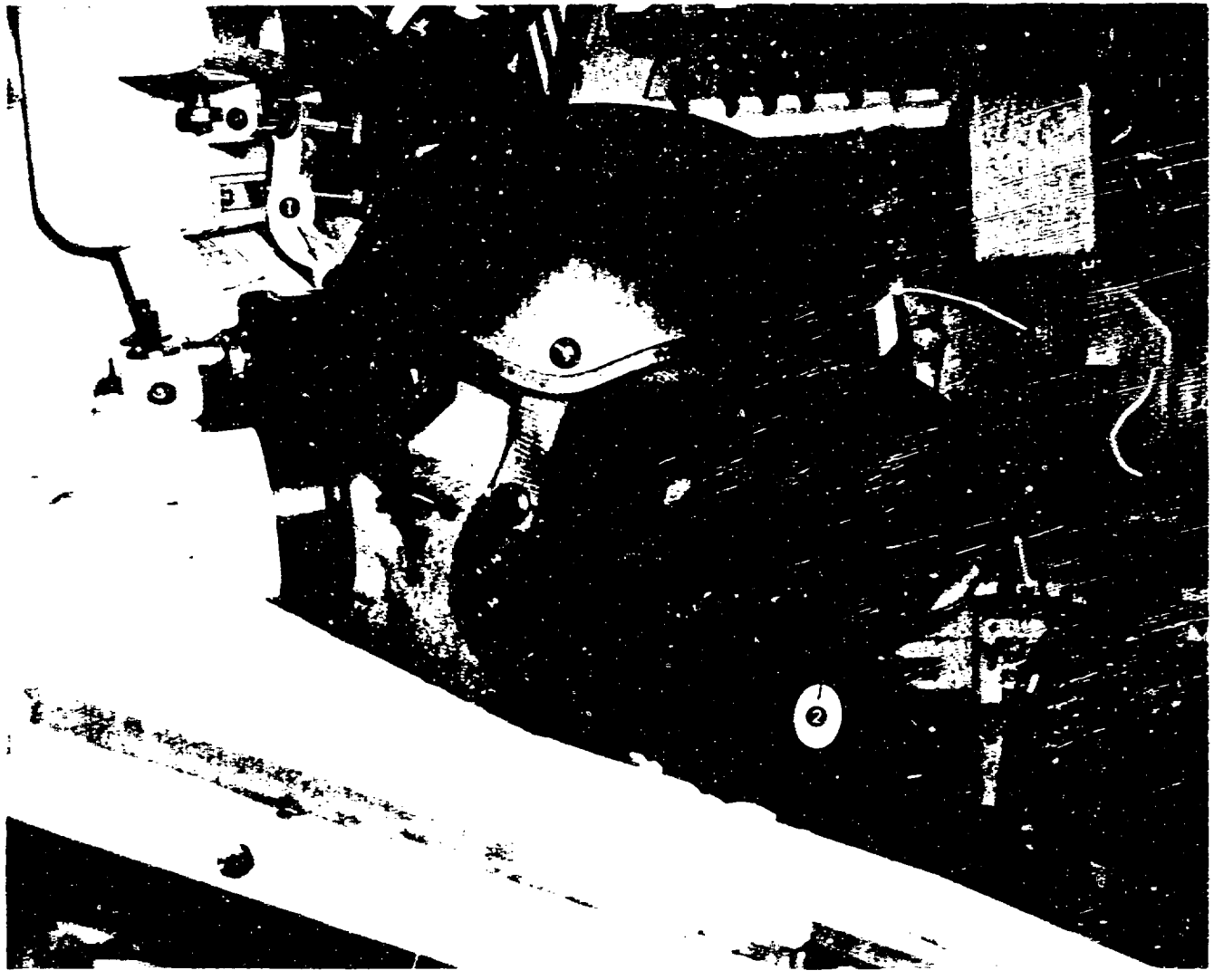


Fig. 28. M551 (Sheridan) gunner viewing with M119 telescope, full bar browpad, type 5, forehead against browpad, DH-132 helmet tilted back.

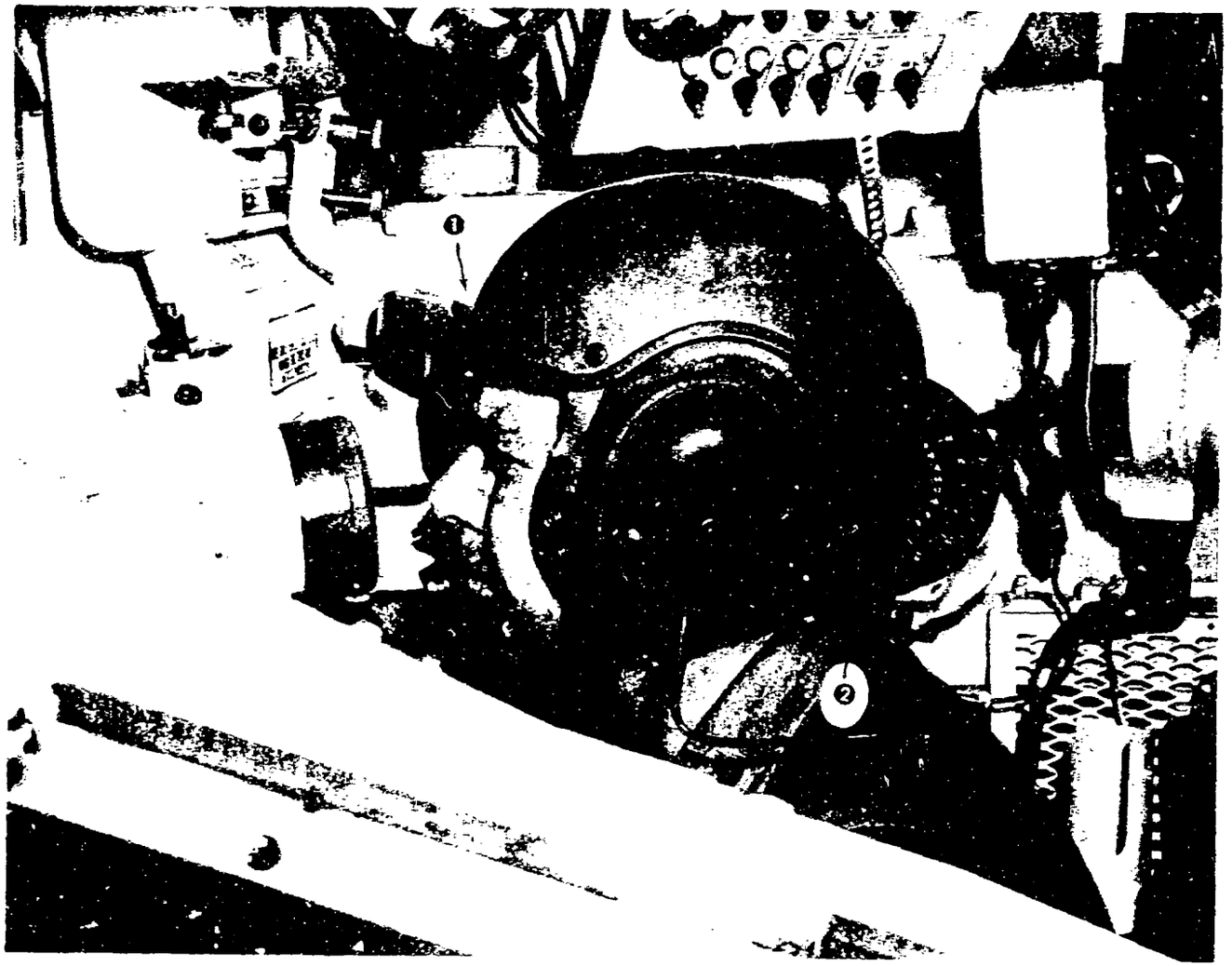


Fig. 29. M551 (Sheridan) gunner viewing with M44 Periscope (night sight), full bar browpad, type 5, DH-132 helmet against browpad.

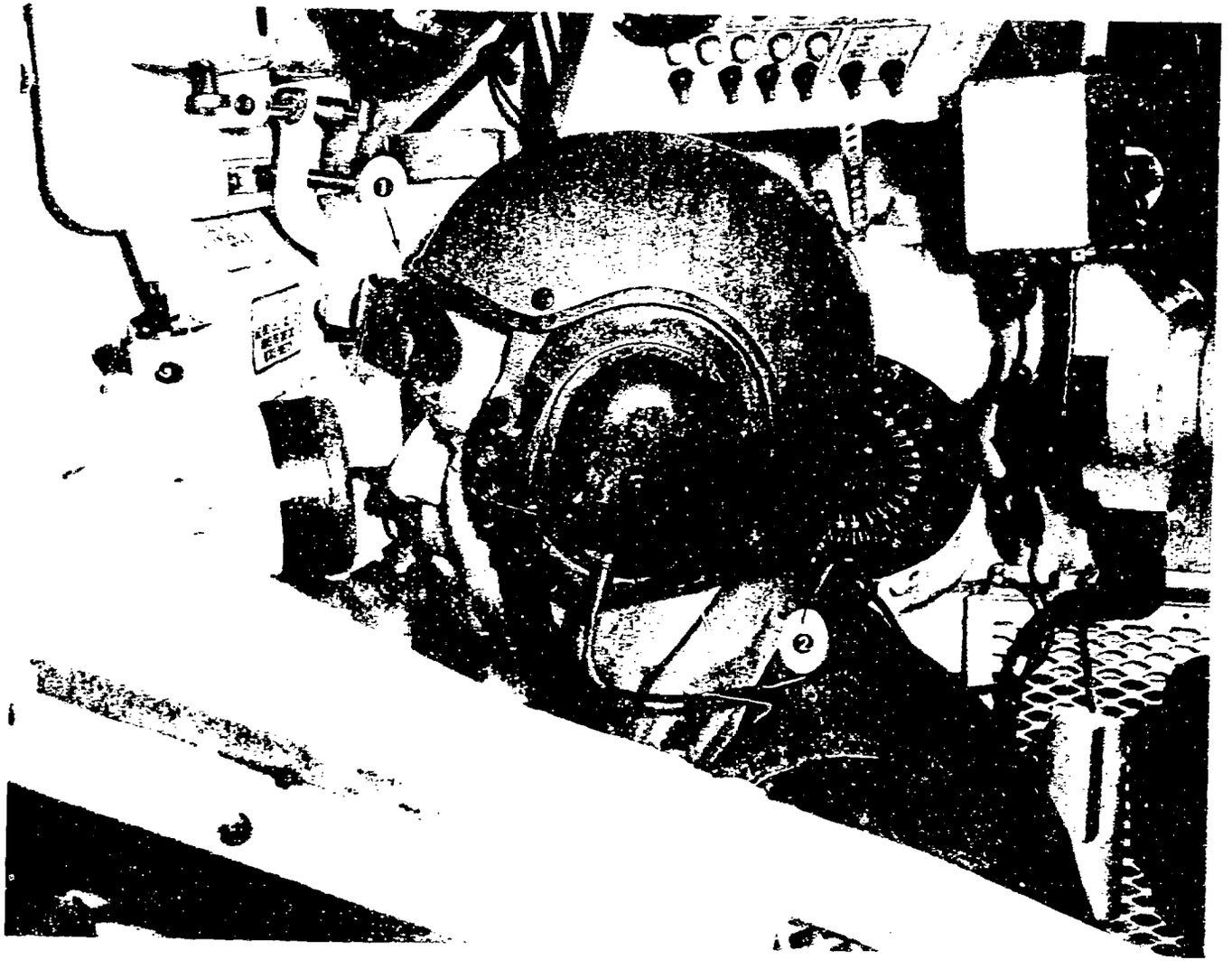


Fig. 30. M551 (Sheridan) gunner viewing with M44 periscope (night sight), full bar browpad, type 5, forehead against browpad, DH-132 helmet tilted back.

Compatibility with Representative Associated Protective and Vision Devices

Figures 31 and 32 illustrate two methods of donning and wearing laser goggles with the DH-132 Helmet. Both methods require tilting the helmet rearward.

Wearing the laser goggles as shown in Figure 31 causes the plastic body to deform on both sides of the face, in the areas pointed out by indicator 1. This deformation does not allow a proper fit, and the seal around the eyes and nose is compromised enough for reflected beams to enter.

Also, wearing laser goggles with the strap on the outside means that the strap must pass across the ear cup (indicator 2, Fig. 31), thus causing uncomfortable pressure at the top of the ear cup. It is not known whether this pressure degrades the ear cup's protective attenuation.

The manufacturer's description of the DH-132 states "Affix rear elastic strap as shown in Fig. 5. This strap also acts as a goggle-strap retainer." Our assessment shows that this rear strap is too low to retain the laser goggles.

Figure 32 shows the most effective way to wear the goggles for eye protection. However, placing the retaining strap between the ear-cup seal and the head, could cause an acoustical leakage. Raising the goggle strap above the ear cup would deform the plastic goggle body, causing discomfort. Additionally, this method of wearing the laser goggle forces the user to remove the helmet before he can don or remove the goggles; this is particularly undesirable for the commander of the vehicle (tank), as well as for the other crewmen.

Figure 33 shows how the laser goggles may be stored on top of the DH-132 Helmet, when the goggles are worn as shown in Figure 31.

Two methods of donning and wearing the M1944-type, wind, sun and dust goggles (driver) are illustrated by Figures 34 and 35. Both methods require tilting the helmet rearward on the head. However, wearing the goggles with the restraining strap outside (Fig. 34), causes additional pressure on the ear cups; also, the frame of the goggle overlaps the leather snap-fastener mount, creating a pressure point there and breaking the goggle seal. Figure 35 shows the most effective way to wear the M1944-type goggle. While this method does give a better seal, the restraining strap lies between the ear-cup seal and the head. Thus the helmet must be removed before donning and removing the goggles.

Figure 36 shows the M18 I.R. binoculars in position for viewing while wearing the DH-132 Helmet. There appears to be no compatibility problem.

Figure 37 shows a crewman wearing the prototype SU50 Electronic Binoculars (night vision) with the DH-132 Helmet. Figure 38 shows the crewman in the driver's station of the M551 vehicle, wearing the SU50 Electronic Binoculars and the DH-132 Helmet. Figure 39 shows a man wearing the SU50 Electronic Binoculars with the standard T-56 Helmet in the M551 vehicle-driver station. Since this binocular is in development, it is shown here for information only. Nevertheless, it seems clear that both helmets will present compatibility problems, which need to be resolved.

Comparing Figures 38 and 39, the DH-132 Helmet offers significantly more clearance between head and hatch roof than the standard T-56 Helmet.

Fig. 31. Laser goggles-wearing of laser goggles with strap worn outside of DH-132 helmet.

Fig. 32. Laser goggles–wearing of laser goggles with strap worn under the DH-132 helmet.

Fig. 33. Laser goggles positione[illegible] top front of DH-132 helmet

Fig. 34. Goggles (M1944 type)-wearing of goggles with strap worn on outside of DH-132 helmet.

Fig. 35. Goggles (M1944 type) wearing of goggles with strap worn under the DH-132 helmet

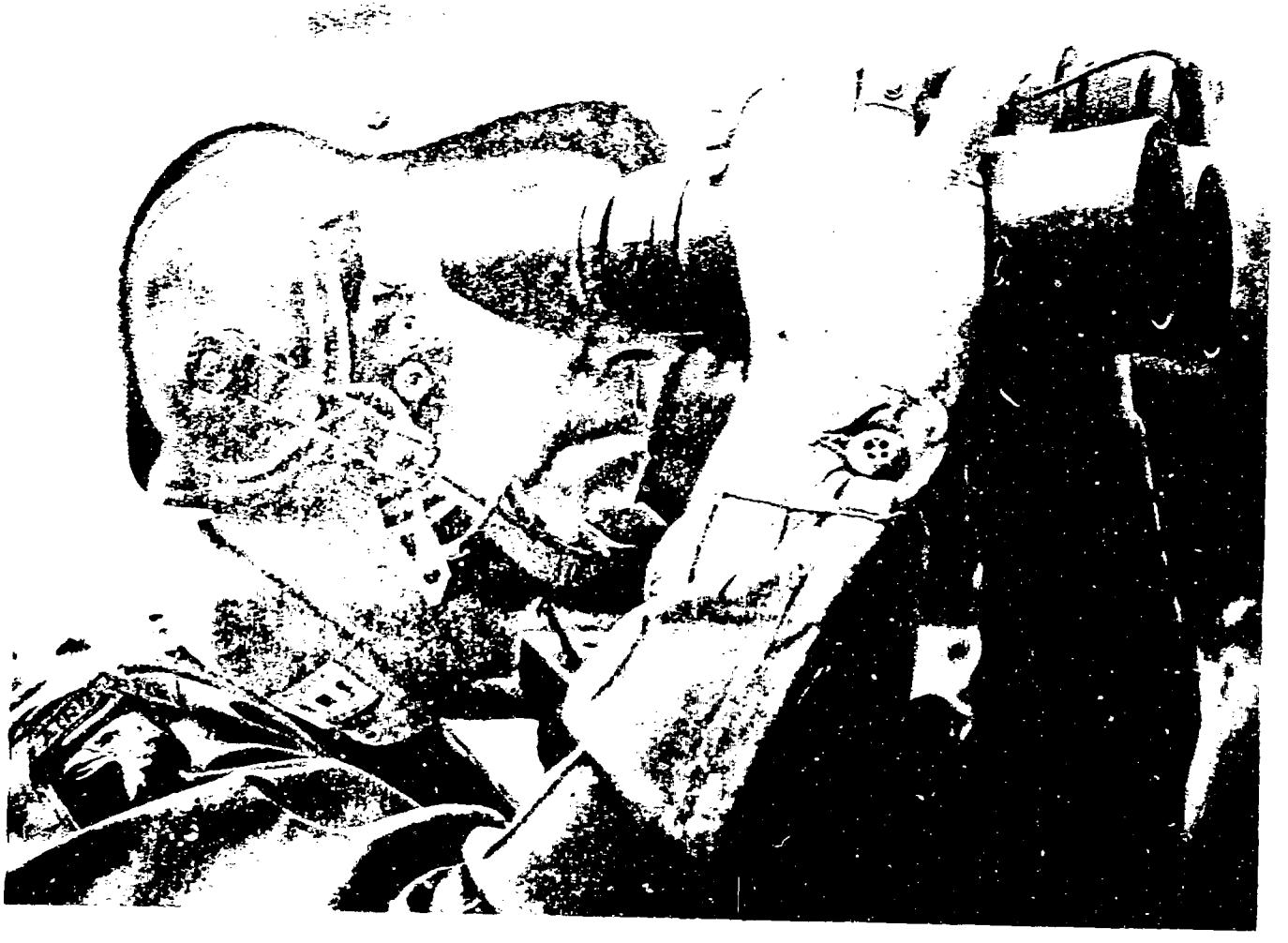


Fig. 36. M18 I.R. binoculars positioned for viewing.

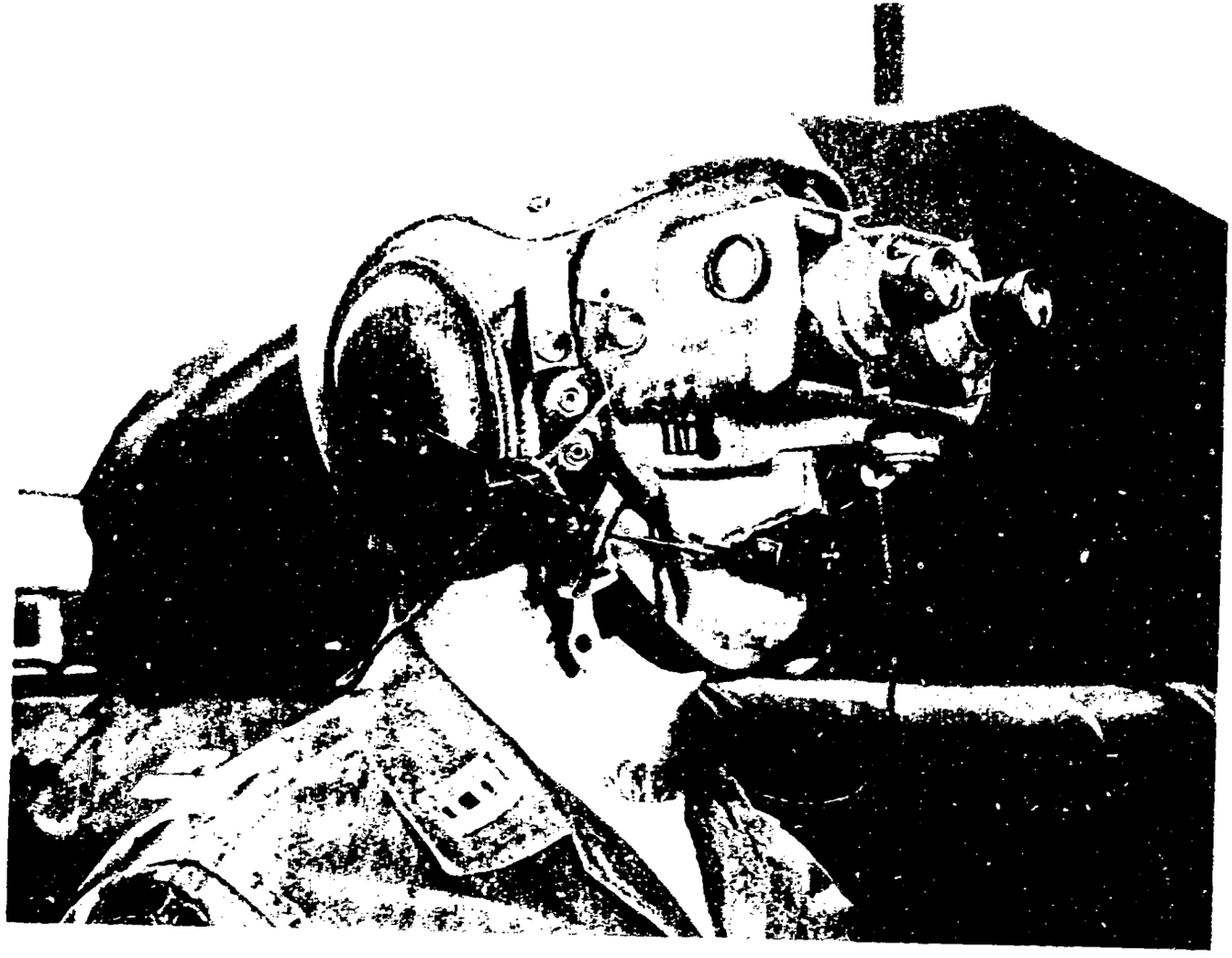
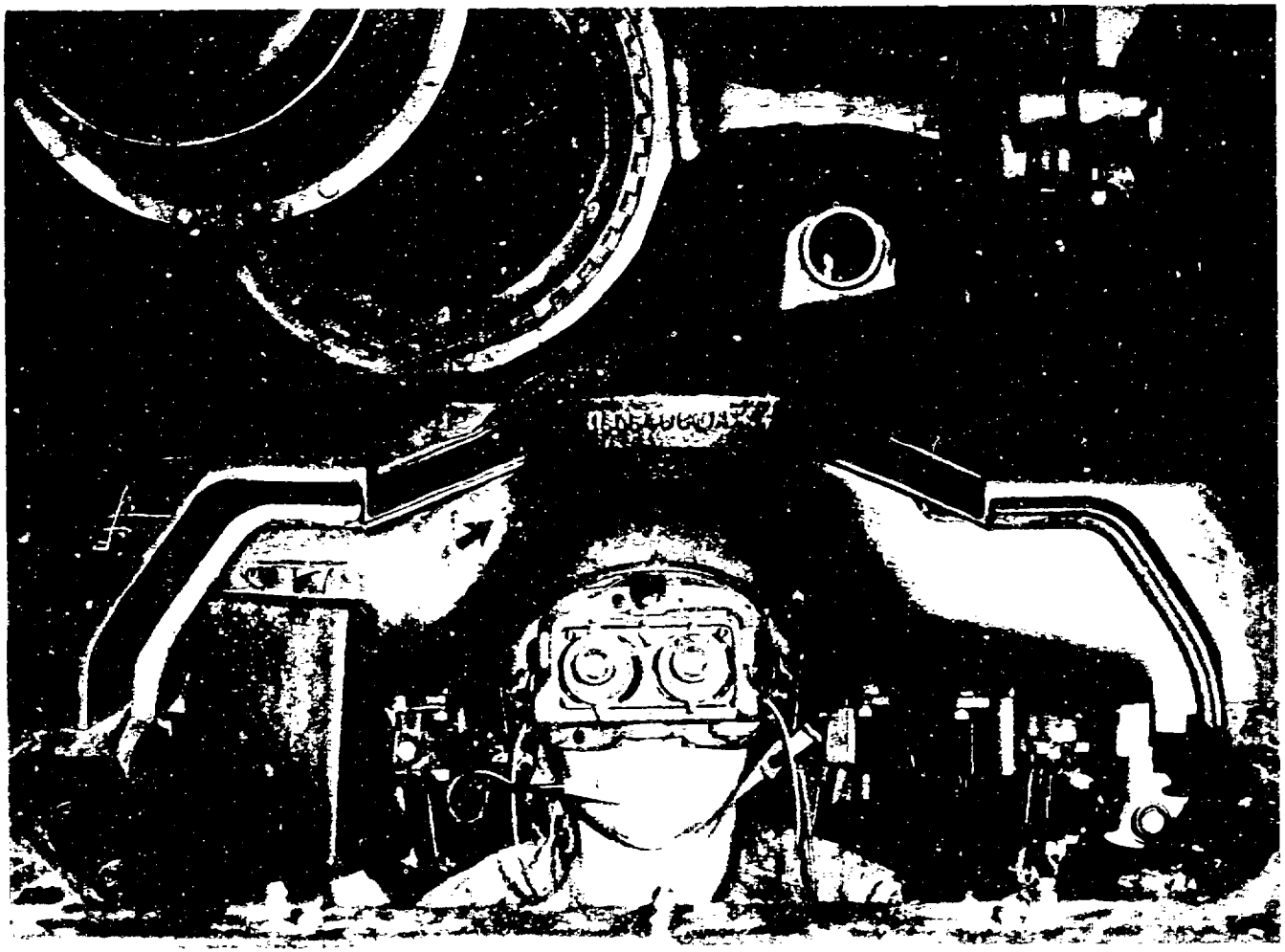


Fig. 37. SU50 electronic binoculars (night vision) positioned for viewing.



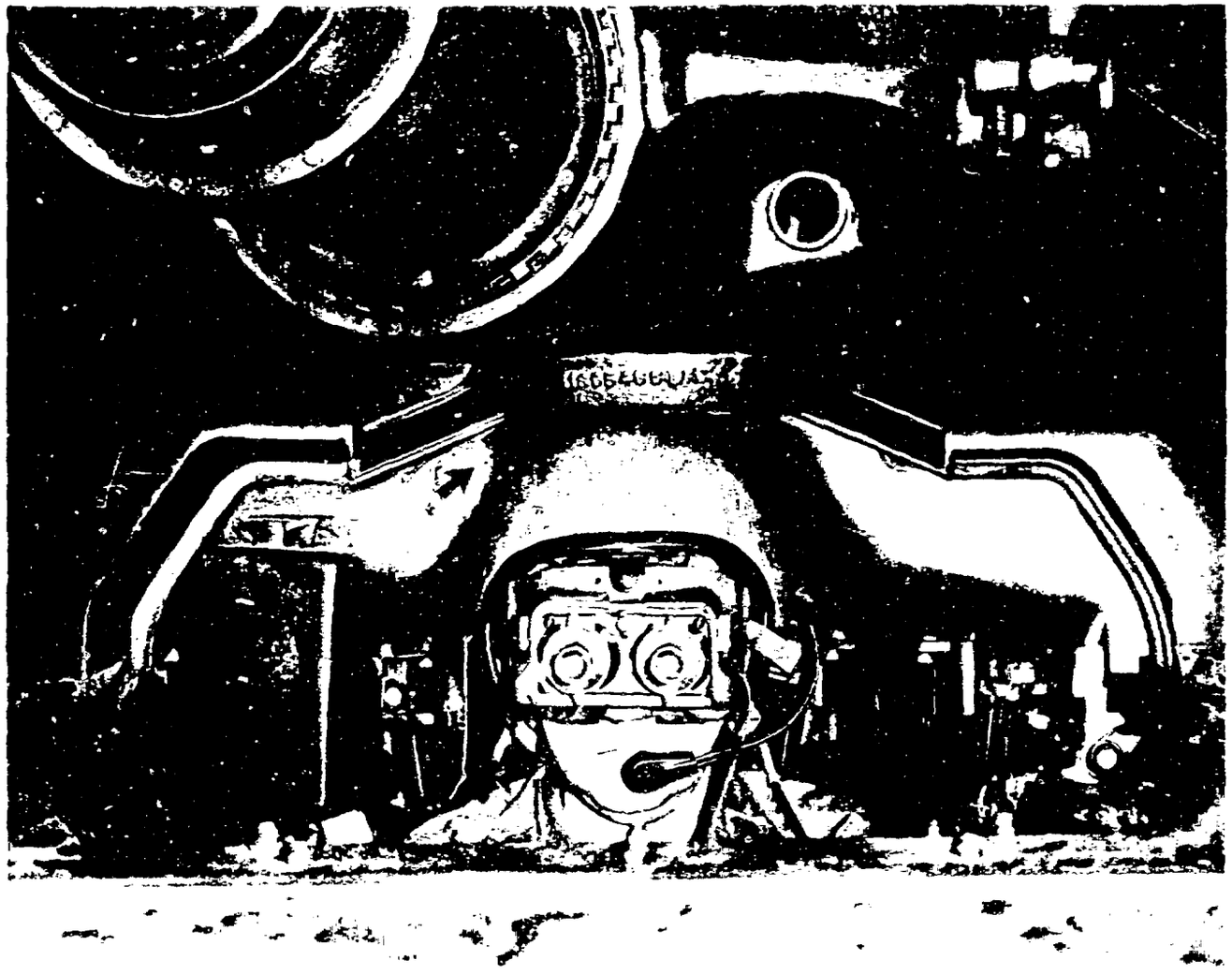


Fig. 39. M551 (Sheridan) – driver in position, open hatch, wearing SU50 electronic binoculars with T56 helmet.

Figure 40 shows a crewman wearing the DH-132 Helmet liner with the M25A1 Protective Mask. Indicator 1 shows the ear cup's position in relation to the left upper forward head-harness adjusting buckle. Indicator 2 shows how the buckle deforms the ear-cup seal.

In summarizing the compatibility of the DH-132 Helmet and standard T-56 Helmet with associated vision and protective equipment, neither helmet affords an effective interface with the associated equipment except for the M18 I.R. and daylight-viewing binoculars, such as the M3, M15A1 and M17A1 types. These incompatibilities cannot be attributed entirely to the design and features of the helmets themselves, but must also be referred to the associated equipment, such as the browpad, laser goggles, the SU50 Electronic Binoculars, M25A1 Protective Mask, etc.

However, it would appear that the "new" item the DH-132 Helmet--should be designed to achieve maximum compatibility with the "old" items i.e., material currently in use (fielded inventory) since they are standard. Obviously, optical devices should also redesigned to improve compatibility. This is the subject of a continuing program.

Field-of-View Field Study (Preliminary)

A preliminary field study was planned and conducted to determine whether the field of view shrinks progressively when the helmet is positioned against and in the browpad, as shown by Figures 12, 19, 21 and 23.

The study was an Angular Field of View Measurement, as defined by paragraph 148b, TM 9-258, dated May 1966. The study utilized the M60A1 Tank with the M31 gunner's periscope (FOV 8^{0} + or 141.6+ mils) and the Type 1 browpad (Fig. 4). Azimuth measurements were taken from the azimuth indicator. There were three subjects, who each performed 20 trials (10 right and 10 left) for each of the six conditions. After each trial, the subject removed his head from the browpad, repositioning it before beginning the next trial.

Condition I was designed to generate control data under the most ideal condition (bareheaded), to measure the subject's (crewman's) capability of achieving the design capability (FOV 8^{0} + or 141.6+ mils) of the M31 periscope.

As seen in Table 1, even condition I (the most ideal) shows an initial loss of approximately 4 mils or 3 percent in field of view, because of human error or other variables.

As measured against condition I (the control), condition II shows loss of 18.9 percent in field of view (comparable to a 26-mil loss). This indicates that removing the shell of the DH-132 Helmet and placing the liner itself in and against the browpad, gives a different eye position than condition I.

Condition III required positioning the DH-132 Helmet (shell and liner assembly) against and in the full browpad, Type 1. This produced a loss of approximately 54.3 percent in field of view, which is comparable to an approximate loss of 74.6 mil or 75 meters at 1000 meters range. This finding indicates that the shell does not conform to the configuration of the browpad as easily as the liner did, consequently displacing the eye much further behind the position for proper eye relief (exit pupil plane).

Fig. 40. M25A1 protective mask-protective mask harness (1) buckle deforming DH-132 helmet (2) ear seal.

Condition IV required positioning of the standard T-56 Helmet in and against the Type 1 full browpad. The results in Table I show that the field of view was 75.6 percent less, or about 104 mils smaller. This is equivalent to a loss of 104 meters at a range of 1000 meters.

Comparing the percentage losses in field of view for conditions III and IV, indicates that the DH-132 Helmet has a lesser frontal stand-off distance than the standard T-56 Helmet. Thus the DH-132 is an improvement.

Conditions V and VI required crewmen to tilt the DH-132 and the standard T-56 helmets backward toward the rear of the head. This condition then became comparable to condition I: forehead and face against adjusted browpad.

Under conditions V and VI, field of view was larger—by 2.2 percent and 1.6 percent respectively—than in condition I. This improvement may be due to learning during each subject's 120 trials. It may well be that the subjects also made a greater effort to compensate for the bulk on their heads.

When conditions III and V are compared with conditions IV and VI, indications are that the DH-132 Helmet gives a wider—and thus better—field of view. However, neither helmet interfaces with the browpad acceptably when crewmen must position the helmet in and against the browpad. A loss in field of view of a magnitude caused by conditions III and IV would definitely have an effect on system performance: i.e., target detection, identification, acquisition, gun laying and tracking.

In assessment of this FOV study, consideration must be given to the probability that the results will differ somewhat from vehicle to vehicle, or equipment, to a greater or lesser degree. However, this study has considered representative equipment and conditions.

FINDINGS

This assessment of the compatibility among crewman, protective equipment, viewing equipment, and the system interfaces, leads to the following findings:

Design Analysis

a. Realizing the maximum noise-attenuation potential depends heavily on fastening and adjusting the chin strap properly.

b. Fit-adjustment features do not seem to effectively accommodate the variable anthropometric features of the head: i.e., head height, independent fore-and-aft and vertical movement of the ear cup, etc.

c. Wearing the helmet produced inconvenience and discomfort, such as pressure on the forehead (producing a waffle effect), heat (or perspiration on scalp, wetness of hair), irritation under chin after wearing the fastened and adjusted chin strap, and difficulty in operating directional snap fasteners.

The DH-132 Helmet requires two modes of wear: (1) normal attitude (Fig. 1), which achieves maximum noise attenuation, bump protection, communication capabilities, etc., but does not interface effectively with vehicular equipment, such as fire-control equipment (browpads); (2) an operational attitude (Figs. 13, 16, 20, 22, 28) that requires compromises—readjustment to maintain maximum noise attenuation and communication capabilities, and forfeits full bump protection in the operational environment—so the crewman can interface with the equipment (browpads, etc.) without degrading total system performance (i.e., target detection, identification, acquisition and tracking).

The design of the DH-132 Helmet does not allow an effective interface with current standard browpads (Figs. 5, 6, 7, 8, 9, 10, 11) unless the helmet is tilted rearward, which requires readjusting the chin strap and ear cups. However, this mode is time-consuming to accomplish and forfeits full bump protection.

Addressing the browpad when wearing the DH-132 Helmet in the normal attitude (Fig. 12), means reducing the field of view by approximately 54.3 percent. However, with the standard T-56 Helmet, the corresponding loss would be about 75.6 percent.

Microphone

a. Adjusting the microphone boom disturbs the ear cup position. Yet the microphone must be readjusted when changing the DH-132 from a normal mode of wear to an operational mode.

b. The right ear-cup mounted microphone boom of the DH-132 Helmet contacts the traversing gear housing when the crewman addresses the browpad on the M44 gunner's periscope in the M551 ARAAV. This makes it difficult for him to position and align his eye.

c. The microphone, supported by a right ear-cup mounted microphone boom, strikes the full-face-type browpad, and becomes entangled when the gunner must turn his head left to view the panel. The gunner's head motion is predominantly left, because of his location.

The DH-132 Helmet requires less ceiling (roof) height than the standard T-56 Helmet (Figs. 38 and 39). The DH-132 Helmet has less front stand-off than the standard T-56 Helmet.

As far as the compatibility and interfacing with associated protective equipment and vision devices—i.e., laser goggles, M1944-type-driver goggles (sun, wind and dust), the prototype SU50 Electronic Binoculars (night vision)—neither the DH-132 Helmet nor the standard T-56 Helmet affords an effective interface.

CONCLUSION

It is concluded that the design of the DH-132 Helmet does not solve the compatibility and interface problems characterizing the standard T-56 Helmet and its associated equipment and system components.

As an independent helmet or a component of a protective system, the DH-132 Helmet has not taken advantage of the human engineering design considerations required to insure that the armor vehicle crewman can utilize its communication, bump-protection and noise-attenuation capabilities effectively, thus potentially forfeiting the required full protection against operational conditions.

RECOMMENDATION

Since this evaluation revealed that the DH-132 Helmet poses a number of interface problems, it is recommended that further evaluations be conducted for other candidate helmets; from the results, data design requirements can be generated to correct these interface problems before a new helmet is fielded.

APPENDIX A

SUBJECT: Notes taken by Respirator Branch, DED, EA test of DH-132 M25A1

The following information was furnished as an interim report from DED, EA by telephone on 9 June, pending forwarding of written report.

a. The test method included fitting, wearing and CS testing. Conditions included helmet and no mask, mask and no helmet, mask and control helmet (T-56), and mask and DH-132 Helmet. While wearing the helmet-mask combination, the subjects were exposed to a cloud of CS and were required to doff and don the helmet three (3) times in the cloud to determine if the mask seal was broken.

b. Results:

(1) Four of 15 subjects leaked donning the T-56 Helmet

Six of 15 subjects leaked donning the DH-132 Helmet

(2) Eight of 15 subjects wearing the T-56-6 Helmet indicated that the helmet and the mask interfered in the forehead area.

Six of 15 subjects indicated this condition with the DH-132

(3) Twelve of 15 subjects indicated that the leather face of the ear cups of the DH-132 came in contact with the M25A1 facepiece edge; however, there were no complaints of interference with vision.

(4) Since the chinstrap is required to be used for maximum stability and noise attenuation, and drawn up snugly, on the DH-132 this was examined to ascertain if the peripheral seal of the mask was broken. Two of four subjects leaked.

(5) No subjects spoke of discomfort, but fitting was more difficult in large size.

c. Recommendations:

(1) Chinstrap concept should be reevaluated since it does contribute to leaks of the M25A1 Mask.

(2) Sizing tariff should be examined.

d. In additional discussion, relative to the inability to decontaminate the helmet, hood wearing was discussed. Since the M5 hood is an under-the-helmet hood, and obviously offers no helmet protection, EA was requested to comment on the feasibility of wearing the M7 hood over the helmet in a pressurized mode. They concurred that the M7 would be effective in this mode.

e. With respect to the current procedure for decontamination, the M13 Decon and Reimpregnation kit is used. If this decon is not successful; e.g., the residual contamination is too great, then the equipment must be disposed of.

APPENDIX B

Mr. Houff/rh/3901

AMXRD-HEL

28 June 1972

SUBJECT: Attenuation Evaluation DH-132 Helmet

Commanding General
U. S. Army Test and Evaluation Command
ATTN: AMSTE-BB (Mr. R. McCormack)
Aberdeen Proving Ground, MD 21005

1. Human Engineering Laboratory (HEL) ran attenuation tests comparing the DH-132 attenuation in the chin strap fastened versus unfastened conditions. These are the attenuation results that HEL obtained.

a. When the helmet is worn in the normal attitude with the chin strap fastened, the attenuation ranged from 6.7db at 75 and 125Hz up to 42db at 4,000Hz (see Inclosure 1).

The MN is met at only 2 frequencies - 3,000 and 4,000Hz with the chin strap fastened.

b. These figures do not correlate with those found by Camp (Letter Report 25 May 1970) of 15.6db at 125Hz to 41.8db at 4,000Hz; however, it is understood that the DH-132 tested by Camp was unmodified giving him a larger ear cup volume which provided greater low frequency attenuation.

2. From a human factors engineering point of view, we are concerned about the loss of attenuation which will occur when the chin strap is not fastened as will most probably prevail in normal operation. We found a significant loss of attenuation when the chin strap is not fastened. This loss of attenuation ranged from 2db at 75Hz, 3db at 125Hz, to 8.7db at 8,000Hz (see Inclosure 1).

The MN is met at only 1 frequency - 4,000Hz - when chin strap is not fastened.

3. A review of the test performance of the three subjects was made to determine if there was a difference in subject performance. It appears that one reason for the difference noted may be the head (face) shape, for example:

PF	Square Face	Least Loss of Attenuation
BR	Eliptical	Intermediate Loss of Attenuation
DT	Pointed Chin	Most Loss of Attenuation

The face shapes may affect the seal of the ear cup at the bottom - front when the chin strap is not fastened.

4. In summary, HEL attenuation tests showed that:

a. There is a significant loss of attenuation when the chin strap is not fastened.

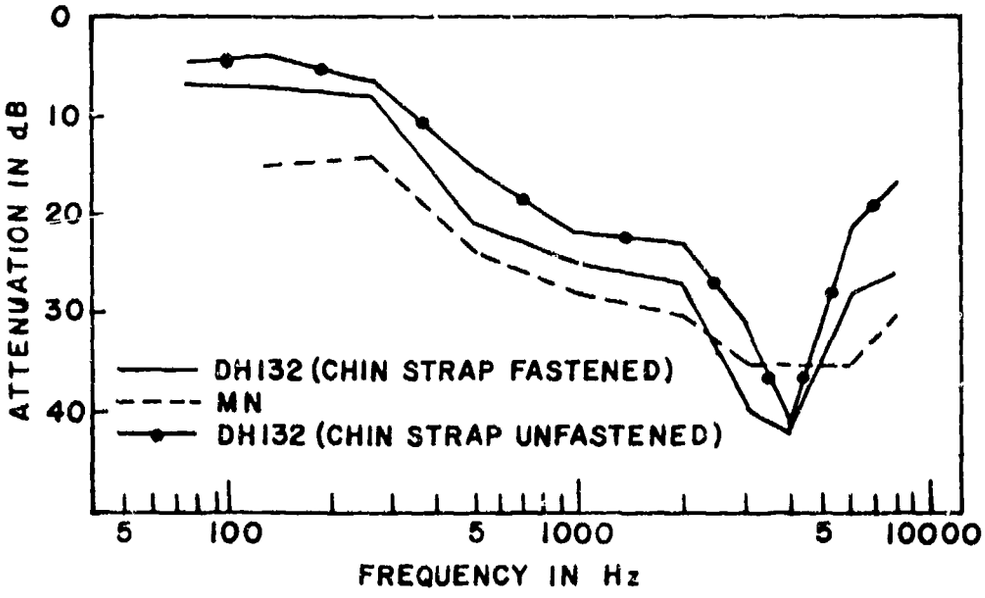
b. The DH-132 tested does not meet the MN by as much as 8.3db at 125Hz due to the reduced volume of the ear cup.

5. Data summary is at Inclosure 1.

6. Full scale attenuation tests should be conducted to validate these findings. It is possible that further redesign is indicated to accomplish the required attenuation.

1Incl
as

JOHN D. WEISZ
Director



Frequency (Hz)	DH132 Attenuation		
	Strap Fastened	Strap Unfastened	Difference
75	6.7	4.7	2.0
125	6.7	3.7	3.0
250	8.0	6.3	1.7
500	21.2	15.3	5.9
1000	25.3	22.0	3.3
2000	26.7	23.2	3.5
3000	38.7	31.3	7.4
4000	42.0	42.0	0
6000	28.0	22.2	5.8
8000	25.7	17.0	8.7